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DRAFT
PHASE II FEASIBILITY STUDY
Maryland Sand, Gravel and Stone Site
Elkton, Maryland

Dames & Moore

7101 Wisconsin Avenue, Suite 700, Bethesda, Maryland 20814



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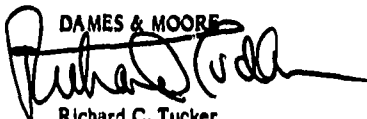
Re: Draft Phase II Feasibility Study
Maryland Sand, Gravel and Stone Site
Elkton, Maryland

Gentlemen:

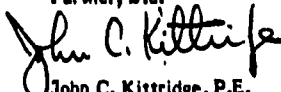
On behalf of the Steering Committee for the PRP's, enclosed are 8 copies (Mr. Christopher Corbett) and 4 copies (Mr. David Healy) of the Phase II FS report for the Maryland Sand, Gravel and Stone site.

Yours very truly,

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LIST OF ACRONYMS

ARAR	Applicable or relevant and appropriate requirement
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
EA	Endangerment assessment
EEA	Eastern Excavated Area
FS	Feasibility study
GAC	Granular activated carbon
MSGs	Maryland Sand, Gravel and Stone
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
msl	Mean sea level
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and maintenance
PCB's	Polychlorinated biphenyls
PRP	Potentially responsible party
RMCL	Recommended maximum contaminant level
ROD	Record of Decision
RI	Remedial investigation
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
TOC	Total organic carbon
TCA	Trichloroethane
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WEA	Western Excavated Area

SUMMARY

The purpose of a feasibility study (FS) is to identify and evaluate a range of remedial alternatives for a site containing hazardous materials as required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), and the National Contingency Plan (NCP). The FS selects the most "cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of the public health, welfare and environment" (40 CFR 300.68(i)). This draft Phase II Report for the Maryland Sand, Gravel and Stone (MSGS) site builds upon a Phase I remedial investigation (RI) and FS conducted in 1985 by a U.S. Environmental Protection Agency (USEPA) contractor and a draft Phase II RI for the site prepared by Dames & Moore in February 1988. The need to prepare an FS for the site was based on direction from the USEPA, although the findings of the endangerment assessment (EA), which is a part of the Phase II RI, indicated no need for remedial action.

The MSGS site is located in Cecil County, Maryland, near the town of Elkton. The site was operated as a sand and gravel quarry. Earth materials were removed from two areas--the Eastern Excavated Area (EEA) and the Western Excavated Area (WEA). About 3 acres of the site in the EEA were reportedly used for the disposal of waste processing water, sludge, still bottoms, and about 90 drums of solid and semisolid waste between 1969 and 1974. Three pits in the EEA were used as surface impoundments, where about 700,000 gallons of waste were disposed. Two hundred thousand gallons of liquid waste were removed from the site in 1974. The drums and sludges that remained were buried onsite in the excavated pits in the EEA under the oversight of the State of Maryland.

S.1 RESULTS OF PHASE I RI

The Phase I RI investigated wastes, surface soils, surface water, sediment, biota, and groundwater conditions at the site, with an emphasis on the EEA. The wastes were found to consist of a variety of chemicals. Surface soils in the EEA disposal ponds and in an adjacent seep were found to be contaminated with some of these compounds. One each of 23 soil and 13 waste samples collected at the site in Phase I were in the WEA and were reported to contain some of these same compounds; the compounds detected are also common analytical laboratory

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contaminants. The Phase I investigation of surface water found evidence of surface water contamination in the vicinity of the EEA but found no evidence of offsite migration of surface water contamination. There was no evidence of contaminants in fish samples collected during Phase I. The Phase I RI focused on shallow groundwater in the EEA and found elevated concentrations of volatile organic compounds (VOC's) in that area. The Phase I RI recommended a Phase II RI to investigate the possibility of waste disposal in the WEA and the possible migration of contaminants into the deep unconsolidated groundwater and bedrock groundwater flow systems.

S.2 RESULTS OF PHASE I FS

The Phase I FS evaluated several remedial options for the site and concluded that remedial measures should be conducted in two phases. The remedial measures recommended were specific to the EEA only and include excavation of buried materials (drums and/or trucks), offsite disposal of hazardous materials at an approved Resource Conservation and Recovery Act (RCRA) facility, and installation of shallow groundwater interceptors downgradient from the waste sources to collect the contaminated groundwater and leachate for treatment at an onsite treatment plant before recirculating to the ponds and shallow groundwater or discharging to Mill Creek. A decision on remedial measures for contaminated soils in the WEA, the lower unconsolidated sand and bedrock water-bearing units, final site closure requirements, and post closure operation and maintenance (O&M) activities was deferred until completion of the Phase II RI/FS.

S.3 RESULTS OF PHASE II RI

S.3.1 RI Objectives

The objectives of the Phase II RI for MSGS were threefold:

- To investigate the possibility of a contamination source in the WEA. The Phase I RI had concluded that the source was in the EEA but had not ruled out the possibility of a source in the WEA. There had been no reports of waste disposal in the WEA.
- To evaluate the extent of soil contamination onsite, primarily in the WEA.

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- To investigate the presence of site-related contaminants in groundwater in the unconsolidated deep and bedrock groundwater systems. Specific objectives of the groundwater investigation included:
 - An evaluation of the extent of intercommunication among the various groundwater systems onsite.
 - An evaluation of the groundwater movement pattern in the deep unconsolidated and bedrock water-bearing units.
 - An evaluation of the concentrations of contaminants, if any, in groundwater in the deep unconsolidated and bedrock units.
 - An evaluation of the effects of contamination, if any, on nearby residential, institutional, and community wells tapping the deep unconsolidated and bedrock units.

S.3.2 Hazardous Substances Investigation

Surface soil sampling, shallow borings, and geophysical studies performed during the Phase II RI did not encounter contamination sources or evidence of general surface contamination in the WEA. The available evidence does not support the hypothesis of hazardous waste disposal in the WEA.

S.3.3 Soil Investigation

Field screening of over 400 soil samples and analysis of 137 soil samples by two laboratories (114 samples by one laboratory, 23 by the other) found virtually no contamination in the WEA, and the soils of that excavated area are considered to be uncontaminated. Soils analyses in the EEA concurred with the Phase I RI, which found significant soil contamination near the ponds used for waste disposal and surface seeps that receive discharge from the upper sand and gravel unit.

S.3.4 Hydrogeologic Investigation

The geology of the MSGS site consists of fluvial Potomac Group sediments that overlie fractured bedrock (gneiss). The sediments are sand, gravel, silt, and clay. Although the sediments exhibit marked lateral variations, there appear to be several laterally consistent lithologic units across much of the site. These units are:

- An upper sand and gravel unit (apparently restricted to the EEA).

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- An upper silt and clay unit (also apparently restricted to the EEA).
- A middle sand unit.
- A middle/lower silt and clay unit (which occurs as two units in the northeast and southwest portions of the site and appears to merge to the southeast; the middle silt and clay is known to be absent in one location in the WEA).
- A lower sand unit, which is present in the northeast and southwest but is absent in the southeast.
- A zone of weathered bedrock (saprolite), present in all locations drilled into bedrock.
- Bedrock.

Information collected in the Phase II investigation indicates that there are four distinct but related groundwater flow systems at MSGS:

- A perched water table system in the upper sand and gravel of the EEA.
- A water table system in the middle sand along the valley of the western tributary to Mill Creek.
- A partially confined system in the deeper sediments.
- A bedrock system.

Groundwater flow in the perched water table system in the EEA flows toward seeps located west, southwest, and southeast of the EEA. Flow in the other water table system (middle sand unit) is generally south. The horizontal component of flow in the deeper units is toward the south-southwest. Vertical gradients between the deeper units are downward in the eastern portion of the site and upward in the southwestern portion.

Groundwater in the upper sand and gravel unit (EEA) contained higher concentrations of VOC's than in groundwater elsewhere onsite. The upper sand and gravel unit in the EEA received the direct impact of waste disposal at MSGS, since wastes were reportedly disposed of in ponds in the EEA.

Water from the deep unconsolidated wells contained traces of metals; these occurrences do not appear to be related to waste disposal activities at MSGS.

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Some VOC's were present in samples from deep unconsolidated units at low concentrations. Groundwater from bedrock wells onsite also contained low concentrations of metals and a few VOC's.

Potential groundwater migration pathways at MSGS include surface seeps from the EEA (which infiltrate into the middle sand unit), leakage through confining units, vertical migration via zones where confining units are absent, and flow via potential conduits created by bedrock-penetrating boreholes in the Phase I RI. It is considered possible that contaminants have migrated from the source area (upper sand and gravel unit in the EEA) through the seeps to the surface where some of the contained volatiles were lost to the atmosphere, reinfiltrated into the middle sand unit, and then were distributed deeper into the system via gaps in the middle silt and clay unit.

Analytical data for groundwater samples collected from offsite wells during the Phase II RI detected metals and VOC's; however, the volatiles were analytical laboratory artifacts. The metals in these water samples were not attributable to MSGS. Data from the Phase I and Phase II RI's do not indicate that contaminants from the site have reached the offsite wells tested.

S.3.5 Surface Water and Sediment Investigation

Surface water and sediment sampling in the Phase II RI focused on isolated ponds in the WEA and on stream drainage that lies between the EEA and WEA. The surface water samples contained a variety of metals and were further characterized by low hardness and a pH of 3.7 to 5.6; however, the pH probably results from natural conditions. No significant concentrations of metals or organic analytes were found.

Sediment samples contained concentrations of metals that were within the range of natural variability. Low concentrations of volatile and semivolatile organic compounds were present in some of the samples.

No pesticides/polychlorinated biphenyls (PCB's) were detected in any surface water or sediment samples collected during the Phase II RI.

S.3.6 Public Health Evaluation

An EA was conducted to assess potential human health effects that may result from exposure to site releases in the absence of remediation. Physical,

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chemical, demographic, and geographic factors were evaluated to assess the extent, if any, of potential harm to the public. Contaminants in the surface soil, sediments, surface water, and groundwater in the upper sand and gravel unit in the EEA were not addressed in the Phase II EA, since those media were addressed in the Phase I EA and are covered in the Phase I Record of Decision (ROD).

The EA process involved the following components--contaminant identification, exposure evaluation, toxicity evaluation, and risk characterization. Exposure pathways were evaluated for two land use scenarios--current use and future use. Exposure doses and risks were calculated under conservative most probable and worst case conditions.

Because the site is open and residential areas are adjacent to the site, public access is possible. Therefore, a potentially complete pathway under the current-use scenario was defined as dermal and incidental ingestion by exposure to the sediment in the WEA. A potential future-use scenario for the site was defined as possible residential development up to the southern boundary. This scenario could increase public access to sediment and could result in groundwater supply wells that withdraw water from the middle sand, lower sand, and bedrock water-bearing units. Potential future exposure routes related to exposure to sediment are the same as those for the current use--dermal and incidental ingestion. Potential future exposure routes related to exposure to groundwater include ingestion, dermal absorption during bathing, and inhalation of vapors during water usage (e.g., bathing and dishwashing).

In summary, the available data and the results of the EA analysis indicate that there are no unacceptable human health hazards posed by groundwater within the middle sand, lower sand, and bedrock units throughout the MSGS. Similarly, no unacceptable human health hazards are posed by surface water, sediments, or soil throughout the WEA at MSGS.

The current-use pathway is only complete for exposure to sediment. Total current-use carcinogenic risks for both the most probable and worst cases are well within the acceptable range, as defined by USEPA. The total noncarcinogenic hazard index is well below the action level of 1.0 for both the most probable and worst cases.

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The future-use pathway is complete for exposure to sediment and groundwater at the southern MSGS boundary. Exposure concentrations for indicator chemicals for the worst-case risk scenario were estimated from analyte concentrations in monitoring wells at the southern MSGS boundary. Total future-use carcinogenic risks for sediment and groundwater are within the acceptable range for both the most probable and worst cases. The hazard indices for future noncarcinogenic exposures are all below 1.0.

S.4 RESULTS OF PHASE II FS

S.4.1 FS Objectives

Although the Phase II RI indicated no need for remedial action at the site, the USEPA directed the potentially responsible parties (PRP's) to complete an FS. The FS evaluates remedial alternatives for groundwater in water-bearing units other than the upper sand and gravel unit.

S.4.2 Remedial Technologies and Alternatives Considered

Technologies that are potentially applicable to groundwater treatment/management at the MSGS site were screened for technical feasibility. Other factors such as public health concerns and costs were also considered, but to a lesser extent. Technologies were grouped into three general categories as follows:

- Groundwater collection/control--Technologies for removing groundwater, preventing recharge, or preventing migration.
- Groundwater treatment--Technologies for removing contaminants from groundwater, either at a separate location or in-situ.
- Management technologies--Technologies for controlling access to contaminated sources and/or for provision of alternative water supplies.

A total of 18 technologies were screened--four groundwater collection/control, seven groundwater treatment, and seven management--in addition to monitoring onsite and offsite wells.

Applicable remedial technologies were assembled into six remedial alternatives that addressed groundwater within the middle sand, lower sand, and bedrock units. The six alternatives addressed, the relevant technologies in each,

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and their ability to meet or exceed public health and environmental requirements are shown below:

<u>Alternative</u>	<u>Technology Categories</u>	<u>Public Health and Environmental</u>
1--No Action	None	Protects public health/environment and meets applicable or relevant and appropriate requirements (ARAR's) at point of use.
2--Onsite Groundwater Monitoring	None (monitoring only)	Protects public health/environment, meets ARAR's at point of use, and allows for detection of changing conditions.
3--Onsite and Offsite Groundwater Monitoring	None (monitoring only)	Protects public health/environment, meets ARAR's at point of use, and allows for detection of changing conditions.
4--Onsite and Offsite Groundwater Monitoring with Immediate Onsite Treatment	Treatment, Collection/Control	Exceeds ARAR's at source and point of use. Potential adverse environmental impact.
5--Onsite and Offsite Groundwater Monitoring with Deferred Offsite and/or Onsite Treatment	Treatment, Collection/Control	Exceeds ARAR's at source and point of use.
6--Onsite Groundwater Pumping with Offsite Disposal	Treatment, Collection/Control	Offsite disposal.

Of the six alternatives, four (1, 2, 3, and 5) were selected for detailed analysis. Alternative 4 was screened from further consideration based on the potential for contamination of the middle sand, lower sand, and bedrock units from pumping from those units prior to completion of Phase I remedial actions. Since onsite treatment options--the preferred option under SARA--exist, Alternative 6, which includes offsite disposal, was also screened from further consideration.

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S.4.3 Results of Detailed Analysis and Recommended Alternatives

The detailed analysis of the remedial action alternatives is summarized in Table S-1. This overview allows the four alternatives to be compared with regard to protection of public health and the environment, ability to meet remedial objectives (ARAR's), and cost. Based on the results of the detailed analysis, a combination of onsite and offsite groundwater monitoring is the recommended Phase II remedial alternative for the MSGS site.

The recommended alternative includes monitoring of seven onsite wells completed in the deep unconsolidated units or bedrock and four offsite wells serving both residences and businesses. Samples would be analyzed for VOC's. Monitoring would be conducted for a period of 5 years. Laboratory data from each sampling would be evaluated.

Reviewing the major screening factors that were used for each alternative, it can be seen that the recommended remedial action has:

- Technical feasibility, using established practices
- No adverse effects to public health and the environment
- Minimal legal and regulatory uncertainty
- Acceptable levels of capital and O&M costs.

This alternative was recommended over the straight onsite groundwater monitoring option due to the additional level of assurance provided to offsite water users. It is recommended over the last alternative, which additionally includes groundwater pumping and treatment, because of continuing uncertainties of the safety and effectiveness of pump and treat actions at the site, and the pending positive impact of the implementation of Phase I remedial action.

In conclusion, the onsite and offsite groundwater monitoring alternative meets the statutory requirements for a selected remedy and is an appropriate Phase II remedial action for the MSGS site.

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TABLE S-1
Summary of Remedial Action Alternatives

Alternative	Costs (\$ x 1,000)		Meets or Exceeds ARAR's for Indi- cator Chemicals	Comments
	Capital	O&M	NPW ^a	
No Action	0	0	0	Yes
Onsite Groundwater Monitoring	2	13	88	Yes
Onsite and Offsite Groundwater Monitoring	2	18	108	Yes
Onsite and Offsite Groundwater Monitoring with Deferred Offsite and/or Onsite Treatment	b 76	b 32	b 55%	Yes
				Provides for tracking of analytes onsite and warning of exceedances.
				Provides for tracking of analytes onsite and offsite and warning of exceedances.
				Similar to above, except that onsite and/or offsite treatment would be initiated if indicated by confirmed monitoring results.

^aNet present worth at 10%.

^bCost data for monitoring and offsite treatment only. Cost data for onsite treatment not generated until effectiveness of Phase I groundwater treatment system can be evaluated.

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1.0 INTRODUCTION

1.1 OVERVIEW OF THE FEASIBILITY STUDY REPORT

Dames & Moore's approach to analyzing remedial alternatives conforms to all requirements under Subpart F of the National Contingency Plan (NCP), as described in 40 CFR Part 300 (Section 300.68). This approach to screening and evaluating remedial options contains all of the elements or procedures described in U.S. Environmental Protection Agency (USEPA) documents that provide guidance for complying with the Subpart F requirements (USEPA, 1986; USEPA, 1985a; USEPA, 1984). The Office of Solid Waste and Emergency Response Directive Number 9355.0-19 addresses requirements promulgated by the Superfund Amendments and Reauthorization Act (SARA) of 1986.

Subpart F of the NCP provides a general framework for conducting a phased evaluation of possible remedial options and for identifying remedial alternatives that are "consistent with permanent remedy to prevent or mitigate the migration of a release of hazardous substances into the environment."

Section 2.0 presents a preliminary screening of remedial action technologies based upon their technical applicability to treating groundwater under the site conditions at the Maryland Sand, Gravel and Stone (MSGs) site. These technologies must address the general response actions outlined in Figure 1-1. These general response actions are recommended by USEPA and are intended to broadly define the nature of the various groundwater treatment technologies that will be considered for use at the MSGs site. In general, they address the issues of source control measures (measures designed to prevent or minimize the migration of hazardous substances from the source) and management of migration measures (measures designed to mitigate the impact of contamination that has migrated into the environment) (USEPA, 1985b).

Technologies that pass the initial screening (Section 2.0) are then combined to form remedial alternatives (Section 3.0), which are screened and then evaluated in detail in Section 4.0. The detailed analyses encompass engineering, institutional, public health, environmental, and cost analyses. The engineering analysis evaluates constructability and reliability to ensure the implementability of alternatives. The institutional analysis examines alternatives in terms of the Federal, State, or local

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requirements, advisories, or guidance that must be considered to protect the public health, welfare, and environment.

The public health exposure evaluation includes base line site evaluation, exposure assessment, standards analysis, and short- and long-term effects of each alternative. An endangerment assessment (EA) has already been conducted as part of the Phase II RI (see Section 1.3 for the scope of the EA). The environmental analysis includes assessment of adverse impacts if no action is taken and the short- and long-term effects of the alternatives. The cost analysis examines capital and operation costs and involves, where applicable, present worth and sensitivity analyses.

Once the detailed analyses are complete, the information is organized into a narrative matrix to compare findings of the evaluations for each alternative. The objective of this summary (Section 5.0) is to ensure that important information is presented in a concise format so that the alternative that provides the best balance between health and environmental protection, and engineering reliability and cost, can be clearly determined (USEPA, 1985a).

1.2 SITE BACKGROUND

1.2.1 Site History

The MSGS site is located in Elkton (Cecil County), Maryland, at 75°53'54" longitude and 30°36'53" latitude on the U.S. Geological Survey (USGS) North East, Maryland, 7.5-minute quadrangle map. Consisting of about 200 acres, the site is located north of U.S. Route 40 and along a tributary to Mill Creek about 3 miles west of the town of Elkton (Figure 1-2). It is situated within the western portion of a triangle formed by Marley Road to the northwest, Nottingham Road to the northeast, and U.S. Route 40 (Pulaski Highway) to the south (Figure 1-3).

The site was previously operated as a sand and gravel quarry under the name Maryland Sand, Gravel and Stone Company. In December 1979, Lester Summers--President of the Maryland Sand, Gravel and Stone Company--informed the Maryland Department of Natural Resources that the site was for sale (Maryland Department of Natural Resources, 1980), although no sale has since transpired.

About 3 acres of the site were used for the disposal of waste processing water, sludge, still bottoms, and about 90 drums of solid and semisolid waste

between 1969 and 1974 (Summers, 1973). On July 16, 1974, 1,300 gallons of flammable products stored in drums were reportedly received and dumped; on August 5, 1974, 5,000 gallons of nonflammable materials were received at the site (Summers, 1974). Pits, excavated onsite, were used as surface impoundments, where approximately 700,000 gallons of waste were dumped (Stone and McGovern, 1982).

On April 27, 1974 (1 p.m.), a pool of chemical waste ignited and burned at high intensity before it was extinguished. The cause of the fire was not determined (Hill, 1974).

Two hundred thousand gallons of liquid waste were removed in 1974. The drums and sludges that remained were buried onsite in excavated pits (NUS Corporation, 1983).

Several seeps can be observed at the site. Several seeps are located south of pond PO1, one seep is in the wooded area east of pond PO2, and other seeps are located downgradient on a hillside west of pond PO3 in the Sedge Meadow Area. The seeps and surface water runoff from the western and southern sections of the site drain into the western tributary of Mill Creek. The Sedge Meadow Area is a hillside located downgradient between pond PO3 and the western tributary of Mill Creek.

A portion of the site located west of the Sedge Meadow Area has undergone excavation; however, the specific nature of the activities that occurred in this area is unknown.

1.2.2 Summary of Previous Investigations and RI Findings

A history of site use, permit and regulatory actions, and remedial actions is presented in Appendix A of the Phase I RI Report.

The Phase I RI/FS was performed at the MSGS site by AEPCO, Inc., under subcontract to NUS Corporation, a regional contractor for the USEPA. The objectives of that RI/FS were to:

- Characterize the types and extent of contamination
- Evaluate alternative remedial actions for the MSGS site
- Recommend a cost-effective remedial action.

The findings of the Phase I RI/FS are presented in the report dated September 4, 1985.

Several unresolved issues were identified as a result of the waste and environmental sampling and analysis program that was conducted during the Phase I RI/FS, namely:

- The existence or absence of contamination in the two deeper aquifers, which underlie a shallow aquifer, and the unconsolidated deep and bedrock aquifers.
- The existence or absence of a contamination source in the Western Excavated Area (WEA) of the site.
- The determination of the extent of soil contamination onsite.

Further study and review of these issues by AEP CO, Inc. (NUS Corporation subcontractor), USEPA, State of Maryland Department of Health and Mental Hygiene (now Maryland Department of the Environment), and NUS Corporation (USEPA contractor) revealed that the conduct of a supplementary RI/FS (Phase II) would be necessary. The Phase II RI/FS was conducted by Dames & Moore to address these unresolved issues.

Surface soil sampling, shallow borings, and geophysical studies performed during the Phase II RI showed no evidence of contamination sources or hazardous waste disposal in the WEA of the site. In addition, soil samples indicated no significant soil contamination.

Groundwater, surface water, and sediment samples in the WEA indicated no significant contamination. An EA for the Phase II RI concluded that there are no unacceptable risks to human health associated with the WEA or with water-bearing units other than the upper sand and gravel unit already addressed by Phase I studies.

1.2.3 Environmental Setting

1.2.3.1 Demography. Cecil County has a population of 60,428, as recorded in January 1984 (Maryland Department of Economic and Community Development, 1984), with a population density of about 172 persons per square mile. This represents approximately 1.5 percent of the total population of Maryland, as

recorded in 1980 by the U.S. Bureau of the Census and the Maryland Department of State Planning. Within a 1-mile radius of the site, there are approximately 150 units housing about 570 residents (Ecology and Environment, Inc., 1982).

The population projection for the years 1985, 1990, and 2000, as estimated by the U.S. Bureau of the Census and the Maryland Department of State Planning, shows a steady growth pattern of 63,500, 66,600, and 70,800, respectively (Maryland Department of Economic and Community Development, 1984).

Elkton, a town of 6,468 residents according to the 1980 Census report (Maryland Department of Economic and Community Development, 1984), is located approximately 3 miles to the east of the site. The town of North East, located approximately 1.8 miles west-southwest of the site, has a population of 1,469.

1.2.3.2 Land Use. Cecil County, located in the northeastern corner of Maryland, is one of the smallest counties in the state, covering only 3,552 square miles. The county is bounded by Pennsylvania to the north, Delaware to the east, Kent County along the Sassafras River to the south, and the Chesapeake Bay and the Susquehanna River to the west. U.S. Route 213 runs north and south in the county, intersecting the Pulaski Highway, U.S. Route 40. U.S. Route 40, as well as Interstate I-95, runs east and west.

Cecil County is becoming less of a rural area partially because of the influence of the growing northern Delaware metropolitan area. Slightly less than 3 percent of the total land, or 6,191 acres, is used for cultivated crops, and about 2 percent (4,526 acres) of Cecil County land is better suited for intensive use as pasture. These pasturelands occupy long, narrow strips along the major streams of the county and are not suited for cultivation because of periodic flooding and poor internal drainage. About 7 percent (15,708 acres) of the land is suited for moderate use as pastureland (U.S. Department of Agriculture, 1973).

Industrial development has progressed in recent years, as exemplified by the production of major chemicals, rubber products, rocket motors, textiles, and industrial wire and cable. Small industries include home construction, luggage manufacture, and medical products.

Land use onsite and within an approximate 1.5-mile radius around the site can be categorized as follows, as of June 1983 (Mats, 1983):

- Urban or builtup land (residential, commercial, industrial, transportation/commercial, utilities, and mixed urban and builtup land).
- Agricultural (cropland and pasture and farmsteads and farm-related enterprises).
- Range (shrub-brush and mixed range).
- Forest (deciduous, evergreen, mixed, and clear-cut).
- Water (natural lakes and ponds and manmade reservoirs and impoundments).
- Barren land (extractional and transitional).

Land use at the project site and within the vicinity of adjacent Marley Road, Nottingham Road, and U.S. Route 40 is categorized below:

<u>Land Use</u>	<u>Area (%)</u>
Mixed forest	55
Clear-cut forest	1-5
Residential	11
Commercial	2
Cropland and pasture	17
Barren lands	11
Mixed urban/builtup land	2
Manmade reservoirs	0-5

Residents near the site rely almost exclusively on groundwater for their water supply and on septic tanks/absorption fields for the disposal of their domestic sewage. Municipal water from Elkton is gradually being extended westward toward the site.

1.2.3.3 Natural Resources in the Vicinity of the MSGS Site. The site covers approximately 200 acres, with two major excavated areas in the eastern and the western portion of the site. The site contains three ponds (PO1, PO2, and PO3), the Sedge Meadow Area, a swamp, an Old Sedimentation Pond, and an upper reach of the western tributary of Mill Creek. The western tributary of Mill Creek, originating at the Sedge Meadow Area, dissects the site, initially flows southward, then turns east south of the Old Sedimentation Pond and joins the eastern tributary of Mill Creek offsite directly east of Ephrata Lane. A number of seeps, springs,

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and intermittent streams are also present at the site. All of the seeps and streams eventually feed to the western tributary of Mill Creek. Several low-lying areas are mostly dry but occasionally fill with water after precipitation.

Most of the site is visually buffered by wooded areas from adjacent properties and roadways, including U.S. Route 40 (Pulaski Highway) to the south, Marley Road to the northwest, and Nottingham Road to the northeast. Nevertheless, traffic noise from U.S. Route 40 is noticeable near the Lower Haul Road, approximately 1,200 feet north of U.S. Route 40.

Other unique onsite features are listed below:

- The site--once a source of sand, gravel, and stone--has been inactive for some time. As a result of the extraction activities for these materials, the site has been drastically modified and is now characterized by undulating terrain. The highest point is 188.5 feet above mean sea level (msl), and the lowest spot at the southeastern corner of the site is just below 94 feet above msl.
- The area surrounding the site is mostly residential. Groundwater is the primary source of drinking water for these residents.
- The site is used extensively by all terrain vehicles, despite efforts to restrict access to the site.
- Seeps are visible directly downgradient from pond PO1, in the wooded area east of pond PO2, and in the Sedge Meadow Area immediately downstream from and west of pond PO3.
- A telephone right-of-way runs along the southern edge of the site.

1.2.3.4 Geology and Hydrogeology. The geology of the MSGS site consists of fluvial Potomac Group sediments that overlie fractured bedrock (gneiss). The sediments are sand, gravel, silt, and clay. Although the sediments exhibit marked lateral variations, there appear to be several laterally consistent lithologic units across much of the site. These units are:

- An upper sand and gravel unit (apparently restricted to the Eastern Excavated Area (EEA)).
- An upper silt and clay unit (also apparently restricted to the EEA).
- A middle sand unit.

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- A middle/lower silt and clay unit (which occurs as two units in the northeast and southwest portions of the site and appears to merge to the southeast; the middle silt and clay is known to be absent in one location in the WEA).
- A lower sand unit, which is present in the northeast and southwest but is absent in the southeast.
- A zone of weathered bedrock (saprolite), present in all locations drilled into bedrock.
- Bedrock.

Information collected in the Phase II investigation indicates that there are four distinct but related groundwater flow systems at MSGS:

- A perched water table system in the upper sand and gravel of the EEA.
- A semiconfined system in the middle sand along the valley of the western tributary to Mill Creek; this system is confined at the WEA.
- A partially confined system in the deeper sediments.
- A bedrock system.

Groundwater flow in the perched water table system in the EEA flows toward seeps located west, southwest, and southeast of the EEA. Flow in the semiconfined portion of the middle sand unit is generally south. The horizontal component of flow in the deeper units is toward the south-southwest. Vertical gradients between the deeper units are downward in the eastern portion of the site and upward in the southwestern portion.

1.2.3.5 Climatology. Cecil County is characterized by a humid, continental climate with well-defined seasons. The Chesapeake Bay and its tributaries and the Atlantic Ocean affect the climate, particularly by moderating extreme temperatures. Table 1-1 shows climatic data for the county, based on Elkton records (National Weather Service, 1941-1960).

The warmest part of the year is during the last half of July, when the maximum afternoon temperatures average near 90°F. Temperatures of 90°F or higher occur about 34 days per year. The coldest period is during late January and

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the beginning of February, when early morning temperatures average 22°F. The average number of days with temperatures less than 32°F is 111.

Freeze data for the spring and early fall are also shown in Table 1-1. The growing season between the last 32°F temperature in spring and the first one in fall averages 181 days at Elkton.

The annual precipitation at Elkton has ranged from a low of 26.96 inches in 1930 to a high of 58.01 inches in 1945. The monthly distribution of precipitation, however, is fairly uniform throughout the year, with slightly higher precipitation levels during August.

The maximum total precipitation for any one month was measured at 15 to 18 inches in August 1955, when two hurricanes crossed Maryland. The average annual snowfall is 21 inches, but there is considerable variation from year to year, ranging from a trace in 1949 to 58.8 inches in 1958. The chances of drought occurring are very low. Generally, the rainfall and stored soil moisture are adequate for good crop growth, but in some years the unequal distribution of summer showers and occasional dry periods at critical stages in crop development made irrigation necessary for maximum crop growth.

Thunderstorms occur on the average of about 30 days per year, with hail occurring about 1 or 2 days per year. Tornadoes are rare and have caused very little damage in the past. Tropical storms affect the county about once each year, usually during August through October. Most of these have caused only minor damage.

Prevailing winds are from west-northwest to northwest, especially in winter months. From May through September, the area is dominated by southerly winds. The average annual wind speed is about 9 or 10 mph. Wind speeds reach 50 to 60 mph and even higher during severe thunderstorms, hurricanes, or winter storms.

1.3 NATURE AND EXTENT OF PROBLEM

The Phase II RI included an EA, which evaluated potential health risks associated with soil, groundwater, and sediments at the WEA and groundwater within semiconfined water-bearing units (middle sand, lower sand, and bedrock units) at the EEA. The available data and the results of the EA analysis--under specific exposure assumptions that are detailed in the Phase II RI--indicate that

there are no unacceptable human health hazards posed by groundwater within the middle sand, lower sand, and bedrock units throughout the MSGS. Similarly, no unacceptable human health hazards are posed by surface water, sediments, or soil throughout the WEA at MSGS.

The current-use pathway at the site is only complete for exposure to sediment. Total current-use carcinogenic risks for both the most probable and worst cases are well within the acceptable range, as defined by USEPA. The total noncarcinogenic hazard index is well below the action level of 1.0 for both the most probable and worst cases.

The future-use pathway at MSGS is complete for exposure to sediment and groundwater at the southern MSGS boundary. Exposure concentrations for indicator chemicals for the worst-case scenario were estimated from analyte concentrations in monitoring wells at the southern MSGS boundary. Total future-use carcinogenic risks for sediment and groundwater are within the acceptable range for both the most probable and worst cases. The hazard indices for future noncarcinogenic exposures are all below 1.0.

Direction was provided by USEPA that an FS be required for Phase II at the MSGS site. In response, this FS will therefore address the issues of control, containment, and disposal and/or treatment of groundwater from the middle sand, lower sand, and bedrock water-bearing units at MSGS.

TABLE 1-1

Temperature and Precipitation at
Elkton, Cecil County, Maryland

Month	Temperature (°F)				Precipitation (inches) ^b		
	Average Daily Maximum	Average Daily Minimum	Maximum ^a (equal to or higher than)	Minimum ^a (equal to or lower than)	Average Total	Less Than	More Than
January	42.4	25.1	60	10	3.46	1.9	6.3
February	44.2	24.9	60	13	2.99	1.9	4.5
March	52.8	31.4	72	19	4.19	2.1	6.3
April	64.9	40.7	82	29	3.60	1.4	6.9
May	75.7	50.8	88	39	4.25	1.4	7.7
June	84.0	59.6	94	48	3.96	1.7	7.4
July	87.9	64.5	96	55	4.35	1.0	8.0
August	86.1	62.9	95	51	5.02	1.4	9.4
September	79.7	55.9	91	42	3.56	1.0	7.1
October	68.6	44.4	84	32	3.23	1.6	6.0
November	56.1	34.6	69	24	2.55	0.8	6.4
December	44.2	26.3	60	12	3.19	1.3	5.8
Yearly	65.6	43.4	99	2	45.35	37.0	52.6

Sources: National Weather Service, U.S. Department of Commerce, 1941-1960.

^aData are based on estimates for 1 year in every decade.

^bPredicted precipitation for 1 year in every decade.

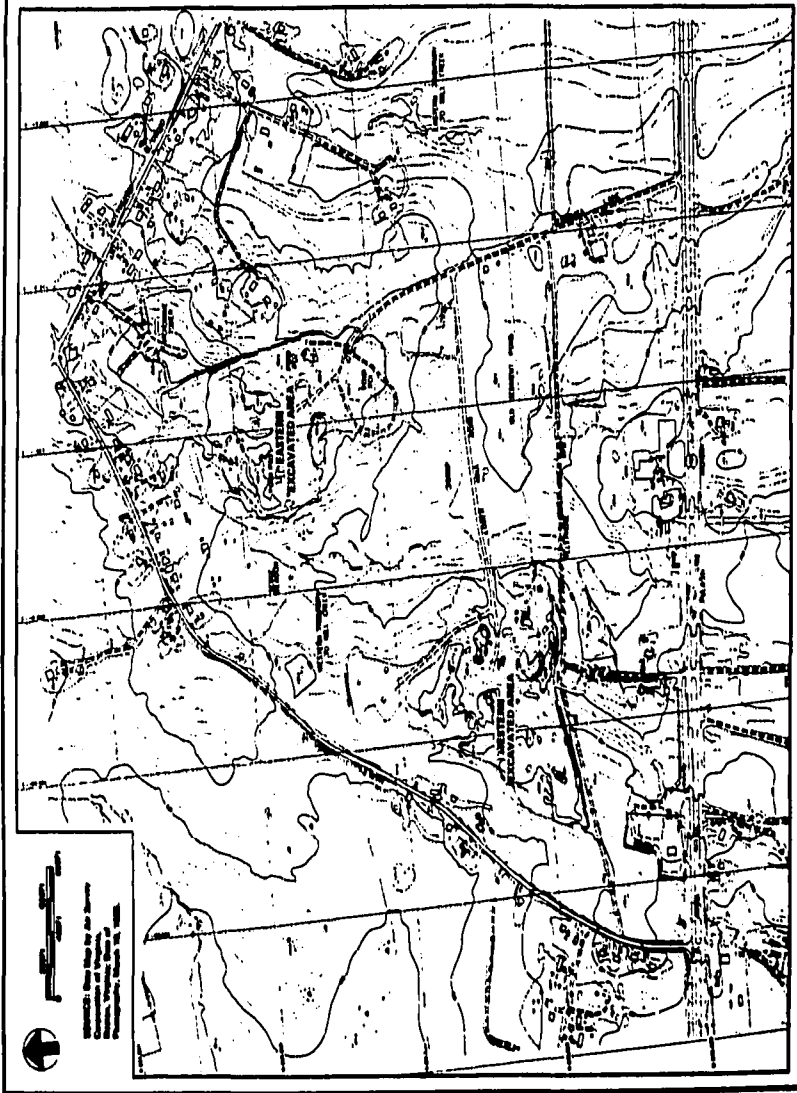
FIGURE 1-1

General Response Actions for Groundwater

Groundwater

- No Action
- Containment
 - Capping
 - Subsurface barriers
 - Access limitations
- Collection/Control
 - Pumping
 - Subsurface drains
- Treatment
 - Biological treatment
 - Chemical treatment
 - Physical treatment

FIGURE 13
SITE MAP



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2.0 PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES

2.1 METHODOLOGY

This section presents a preliminary screening of technologies that are potentially applicable to groundwater treatment/management at the MSGS site. This screening is conducted on the basis of technical feasibility only; other factors such as public health concerns and costs are discussed but will not (at this point) be the primary basis for eliminating technologies from further consideration. The technologies reviewed fulfill the general response actions recommended by the USEPA. The individual technologies were chosen based upon information on the nature and extent of the low levels of contamination found, as well as the environmental setting, which were presented earlier in this report and in the Phase II RI Report. Table 2-1 presents a summary of the preliminary screening.

2.2 GROUNDWATER COLLECTION/CONTROL

Remedial technologies for the control of groundwater contamination can be placed in one of four categories: (1) groundwater pumping, involving the extraction of water from or injection of water into wells to capture a plume or alter the direction of groundwater flow; (2) surface water diversion to control leachate formation; (3) subsurface drains, consisting of gravity collection systems designed to intercept groundwater; and (4) containment barriers, consisting of a vertical wall of low-permeability materials constructed underground to divert groundwater flow or minimize leachate generation and plume movement (USEPA, 1985b).

2.2.1 Groundwater Pumping/Control

Extraction of groundwater from the middle sand, lower sand, or bedrock water-bearing units using groundwater extraction wells is a feasible technology for groundwater collection/control. There are, however, potential serious adverse environmental impacts associated with implementing this technology. These potential impacts involve inducing downward contaminant migration from the water table aquifer into the underlying semiconfined water-bearing units. Section 3.4 addresses this possibility in greater detail.

Groundwater pumping techniques actively manipulate groundwater to contain, divert, or remove a plume or to adjust groundwater levels (prevent formation of a plume). Types of wells used in management of contaminated

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groundwater include suction wells and injector wells. Selection of the appropriate well type depends on the depth of contamination and the hydrologic and geologic characteristics of the aquifer.

Wellpoint systems are best suited for shallow aquifers where extraction is not needed below 22 feet. Beyond this depth, suction lifting (the standard pumping technique for wellpoints) is ineffective. Suction wells operate in the same way and are also depth limited. The advantage of suction wells over wellpoints is their higher capacities. In addition, submersible pumps may be used. For extraction depths greater than 20 feet, deep wells and injector wells are used. Deep well systems are better suited to homogeneous aquifers with high hydraulic conductivities and where large volumes of water may be pumped.

Where plume containment or removal is the objective, either extraction wells or a combination of extraction and injection wells can be used. Extraction wells alone are best suited to situations where contaminants are miscible and move readily with water, where the hydraulic gradient is steep and hydraulic conductivity is high, and where quick removal is not necessary. Extraction wells are frequently used in combination with slurry walls to prevent groundwater from overtopping the wall and to minimize contact of the leachate with the wall to prevent wall degradation.

A combination of extraction and injection wells is frequently used in containment or removal where the hydraulic gradient is relatively flat and hydraulic conductivities are only moderate. The injection well directs contaminants to the extraction wells. This method has been used successfully for plumes that are immiscible with water. One problem with such an arrangement of wells is that dead spots (i.e., areas where water movement is very low or nonexistent) can occur when these configurations are used. The size of the dead spot is directly related to the amount of overlap between adjacent radii of influence; the greater the overlaps, the smaller the dead spots. Injection wells can also suffer from operational problems, including air locks and the need for frequent maintenance and well rehabilitation.

2.2.2 Surface Water Diversion

Surface water diversion is used to control the flow patterns of surface water to prevent the leaching of wastes into groundwater. The results of the Phase II RI

indicated that surface contamination sources are not evident at the WEA; therefore, surface water controls are not applicable at this area. The few analytes detected at the surface along roadways at the WEA were likely derived from the original source area at the EEA. Further, the results of the Phase II EA do not indicate unacceptable public or environmental hazards associated with the analytes detected at the surface at the WEA. The Phase I Record of Decision (ROD) for the EEA calls for removal of contaminant sources (drums and/or cement mixer barrels), which will affect reduction of leachate generation. To supplement excavation, the ROD includes a system of shallow groundwater interceptors downgradient from waste sources. Both the excavation and leachate collection alternatives are considered adequate surface water diversion controls for MSGS; therefore, no additional surface water diversion controls are evaluated.

2.2.3 Subsurface Drains

Subsurface drains include any type of buried conduit that conveys and collects aqueous discharges by gravity flow. Subsurface drains act somewhat like a line of extraction wells. They drain a continuous zone of influence so that groundwater within this zone flows toward the drain. Subsurface drains usually include these components:

- Drain pipe or gravel bed (conveys flow to a storage tank or well). Pipe drains are preferred for hazardous waste sites. Gravel bed or french drains and tile drains are less frequently used.
- Envelope (impermeable downgradient barrier--i.e., plastic sheeting, that conveys flow from the aquifer to the drainpipe or bed).
- Filter (prevents fine particles from clogging the system).
- Backfill (brings the drain to grade, prevents ponding).
- Manholes or wet wells (collect flow and pump discharge to a treatment plant).

Drains perform many of the same functions as a continuous line of wells. They can contain or remove a plume, lower the groundwater table, and keep water away from the waste material. For soils of variable or low hydraulic conductivity and where contamination is shallow, drains are more cost effective than pumping.

Subsurface drains are technically feasible relative to the upper water-bearing unit (water table aquifer) at the EEA because of its shallow depth. This is the preferred groundwater collection alternative for the EEA, selected in the Phase I FS. However, the water table aquifer is not present at the WEA, and the depths to the middle, lower, and bedrock confined units are too great for subsurface drain technology. Therefore, this technology is not further evaluated.

2.2.4 Containment Barriers

A containment barrier is a low-permeability cutoff wall or diversion installed below ground to contain and capture or redirect groundwater flow in the vicinity of a site. If properly built, and if materials of construction are compatible with the waste, this effective technology requires little or no maintenance.

The barrier is typically constructed by excavating a vertical trench and filling it with a bentonite-water slurry. Hydraulically, the slurry shores up the trench to prevent collapse and seals the walls with a filter cake of bentonite to prevent fluid loss to the surrounding soil.

At its base, the slurry wall is usually keyed into a notch in bedrock, a clay deposit, or other low-permeability layer. Good key-in is essential for creation of a complete containment barrier. Alternately, the slurry wall may be left hanging, with no key-in at the base. Such a containment barrier can control floating contaminants but may not be effective for controlling groundwater flow, particularly if there is a downward hydraulic gradient.

The containment barrier may be located upgradient from the site (where it deflects groundwater flow around the site), downgradient from the site (where it provides maximum groundwater flow restriction), or completely surround the site.

Because the hydraulic gradient is downward in some areas at MSGS, a hanging containment barrier is not appropriate. Good key-in cannot be assured due to the great depth to bedrock and the absence of a completely extensive and relatively shallow low-permeability layer. Therefore, containment barrier technologies are not evaluated further.

2.3 GROUNDWATER TREATMENT

2.3.1 Groundwater Treatment at the Surface

Groundwater treatment subsequent to groundwater extraction is technically feasible, assuming that groundwater extraction from the semiconfined water-bearing units can be accomplished without causing unacceptable environmental and public health impacts resulting from inducing downward contaminant migration into the semiconfined water-bearing units. Applicable technologies for groundwater treatment at the surface include air stripping, carbon adsorption, steam stripping, and offsite treatment.

2.3.1.1 Air Stripping. Air stripping is a mass transfer process that transfers volatile compounds in water to gas. It is usually carried out in a packed tower equipped with an air blower, employing the principle of countercurrent flow. Water flows down through the packing, while the air flows upward. The air, saturated with volatiles, exhausts through the top of the tower for treatment, if necessary. Volatile, soluble components tend to leave the aqueous stream for the gas phase.

Air stripping has found widespread use for effective removal of volatile organics from aqueous waste streams. It is cost effective for treatment of moderate to high concentrations of volatiles or as a pretreatment step for cleanup with activated carbon. Air stripping equipment is relatively simple. Startup and shutdown can be carried out quickly. The modular design of the packed towers makes air stripping well suited for hazardous waste site applications (USEPA, 1985b).

Because air stripping is based on mass transfer, the process is most efficient at higher concentrations. Removal efficiencies decrease with decreasing analyte concentrations. Analyte levels at the MSGS site are low, and groundwater could be more effectively treated by carbon adsorption.

2.3.1.2 Carbon Adsorption. Carbon adsorption removes chemical contaminants from water by physical and chemical adsorption of organics onto the surface of carbon particles. Granular activated carbon (GAC) is most frequently used in wastewater treatment. For GAC treatment, groundwater is pumped through a bed of GAC, where close contact with carbon particles promotes contaminant adsorption. Carbon adsorption removes a wide range of organic contaminants and

numerous inorganic contaminants. Adsorption is reversible; the exhausted carbon can be regenerated in either an onsite or offsite thermal regenerator. Offsite regeneration by the carbon manufacturer is usually less costly. Spent GAC units can also be landfilled.

GAC technology is very effective. Carbon adsorption may be an effective method for the removal of contaminants to the parts per billion range. At higher contaminant concentrations, the process may require frequent monitoring to track contaminant breakthrough. Operation costs are modest, but maintenance costs may be high for replacement of carbon and regeneration.

2.3.1.3 Steam Stripping. Steam can also remove organics from aqueous wastes. Steam stripping is a continuous fractional distillation process carried out in a packed tower. Clean steam supplies direct heat to the tower. The contaminated steam condenses, while solvent and "stripped" effluent are the products. This technology is employed for treating aqueous waste contaminated with chlorinated hydrocarbons, aromatics such as xylenes, ketones such as acetone or methyl ethyl ketone, alcohols such as methanols, and high boiling point chlorinated aromatics such as pentachlorophenol. Steam stripping will treat less volatile and more soluble wastes than air stripping and can handle a wide concentration range (from less than 100 mg/l to 100,000 mg/l organics).

2.3.1.4 Discharge to Surface/Pipe to Offsite Treatment Plant. Discharge of extracted groundwater to surface streams or piping to offsite treatment plants is a potentially feasible technology for treating groundwater. Prior to discharge of groundwater to surface water bodies, it is generally necessary to evaluate the chemical nature of the groundwater relative to the assimilative capacity of the water body to provide for nonimpact on the water body. Controls to discharge, such as maximum allowable discharge rates and contaminant levels, frequently become requirements prior to authorization for discharge. An enforcement vehicle such as a National Pollutant Discharge Elimination System (NPDES) permit may be required.

Alternatively, offsite treatment/disposal may be facilitated by piping (or sometimes trucking) of groundwater to an offsite treatment location such as a community wastewater treatment system. This technology is more feasible if a pipeline such as a sanitary sewer system is already in operation near the site.

2.3.2 In-Situ Treatment

In-situ treatment technologies for groundwater include biological, chemical, and/or physical treatment. In-situ treatment technologies can be implemented without groundwater extraction, thereby inducing no additional downward leachate migration into the semiconfined water-bearing units. However, in-situ treatment is severely limited by the techniques available to deliver nutrients, reagents, microorganisms, oxygen, etc., to the geological formations of interest and to recover byproducts of treatment. Heterogeneous formations, such as MSGS, are the most difficult settings in which to apply in-situ treatment technologies.

2.3.2.1 In-Situ Biological Groundwater Treatment. In-situ biological treatment of groundwater has been used to biologically degrade hydrocarbons and other biodegradable compounds in contaminated aquifers. The process, known as bioreclamation, is based on the concept of stimulating microorganisms to decompose the indicator chemicals by the addition of nutrients and oxygen. With the exception of petroleum hydrocarbons, biodegradation is still considered an unproven technology for use with mixed organics.

Even with nutrient addition, sufficient quantities of biodegradable constituents (as measured by biochemical oxygen demand (BOD), total organic carbon (TOC), or chemical oxygen demand (COD)) must be present to provide a substrate for microorganisms. Groundwater normally has very low levels of naturally occurring BOD. Data from Phase I sampling indicate a TOC level of approximately 2.9 mg/l for the deep monitoring well DMW-06. It is unlikely that the middle or lower water-bearing units contain sufficient substrate to support a significant microbial population (Wagner and Kosin, 1985).

This method of groundwater treatment is therefore not recommended for use at the MSGS site.

2.3.2.2 In-Situ Chemical Groundwater Treatment. In-situ chemical treatment of groundwater involves the use of chemical additives to groundwater to mobilize, immobilize, or transform contaminants to a more manageable, or less toxic, form. The in-situ process would involve the surface application or injection of a chemical additive. Some additives may perform more than one of the treatment processes (i.e., immobilization, detoxification) simultaneously. For example, a flushing solution that mobilizes one contaminant may also precipitate, detoxify, or increase

the toxicity of another contaminant. The specific in-situ chemical treatment methods applicable to the middle and lower sand water-bearing units are presented below.

The oxidation state of several organic contaminants in water can be raised (electrons are lost) through the use of an oxidizing agent. Common commercial oxidants are potassium permanganate, hydrogen peroxide, calcium or sodium hypochlorite, and chlorine gas (USEPA, 1985b). This process could be used to treat the aromatic contaminants of concern and to partially strip chlorine atoms from several of the chlorinated compounds. If present, chloroform, being denser than water (approximately 1.5 times), is likely to be layered near the bottom of each water-bearing unit, which could make contact between an oxidizing agent and chloroform difficult.

The oxidation state of organics can be reduced through the use of catalyzed metals. This process has currently only been proven in theory for use with organics and will not be considered further for use at the MSGS site.

As mentioned above, these processes require the delivery of a fluid to the subsurface. Hence, the limitations and applications of injection/extraction wells, drains, surface flooding, and spray irrigation are applicable to chemical in-situ treatment approaches. Other limitations include:

- Contaminated groundwater must be kept within the treatment area.
- Treatment reagents must not migrate away from the treatment area and become contaminants themselves.
- Uncontaminated groundwater must not be drawn into the treatment area and thus be contaminated during the extraction process.
- The potential adverse chemical reactions between soil/waste/water and the treatment reagents must be considered. In addition, the formation of precipitates due to treatment reagents may reduce soil permeability because of clogging.

The technical feasibility of in-situ chemical treatment is a complex function of site geology and hydrology, soil characteristics, waste characteristics, reagent chemistry, and the mode of reagent delivery to the subsurface. The application of these approaches to uncontrolled hazardous waste sites is conceptual or in the

development stage. There are few, if any, engineering and design procedures currently in existence (Drake, 1987).

The complex hydrology of the site and the subsequent difficulty of treating the middle and lower sand water-bearing units without contaminating or further contaminating the bedrock and upper sand water-bearing units, coupled with the experimental nature of the treatment approaches, makes in-situ chemical treatment infeasible at the MSGS site.

2.3.2.3 In-Situ Physical Groundwater Treatment. Physical treatment involves the physical manipulation of the subsurface to immobilize or detoxify waste constituents. This field of treatment is relatively new, and most of the technologies are unproven. The technologies are best suited to areas of shallow contamination with permeable, homogeneous soil conditions. Due to the lack of design information and unproven nature of these technologies, in-situ physical treatment will not be considered for use at the MSGS site.

2.4 MANAGEMENT TECHNOLOGIES

Management technologies are those that provide for public and environmental protection without directly providing source remediation. They are frequently used during remediation construction and/or in conjunction with one or more source remediation technologies. These management measures are frequently arranged with the cooperation of State or local agencies; therefore, it is important to consider public institutional factors carefully before implementation.

2.4.1 Alternative Water Supplies/Drinking Water Treatment

The nearby residences and businesses adjacent to the site utilize well water as their primary water source. Although the EA conducted as part of the Phase II RI indicated that there would be no risks in excess of USEPA's acceptable range associated with the ingestion of groundwater from the middle sand, lower sand, or bedrock water-bearing units, various alternative water supplies and treatment options for existing supplies have been considered to present a complete range of technologies.

A large number of factors are involved in the consideration and design of alternative water supplies. This preliminary screening is intended to review and assess possible options for the site based only on technical feasibility. Design

criteria are typically unknown at this point and are deferred to the detailed evaluation or to actual system design.

2.4.1.1 At-Tap Treatment. This treatment system could be more appropriately termed "well head," or point of use, treatment because the system would be installed on each water supply system between the well and the first point of use on the system. The system would typically consist of activated carbon tanks. These units could be set up to accommodate individual wells, the combined influent from a series of wells, or a central supply area. Capital and O&M costs would vary according to the system capacity and the number of units installed. This section will evaluate the feasibility of individual well systems.

The indicator chemicals found in low concentrations in the middle sand, lower sand, and bedrock water-bearing units are amenable to carbon adsorption. A measure of "adsorbability" is the water solubility of a compound.

The advantages of individual carbon adsorption units are:

- Since treatment systems would be installed only at wells where required, the water would be treated on an "as-needed" basis, and excess capacity, inherent in larger systems, would not be constructed.
- If development and new well installation are controlled in the area (by zoning or other land use ordinances), treatment could be limited to a relatively small number of wells and therefore would be comparatively inexpensive.
- If placed on individual wells, the system would not require a central storage or distribution system.
- This type of system can be readily adapted to an existing water supply system in a residence or small business and can be "tailored" to treat concentrations that may vary between adjoining properties.
- The system should prove reliable in providing potable water, being limited primarily by variations in influent concentrations and maintenance requirements.
- The system may be readily designed so that if system failure occurs due to mechanical failure or an unexpected peak of influent contamination

concentration, only those served by the failed system would be affected.

Disadvantages of this alternative are primarily results of the number and variation of systems installed:

- Each system would have to be individually monitored to determine analyte concentrations before and after treatment and daily water use.
- Because systems can be tailored to concentrations and daily flow, there can be a significant difference in design, carbon use, and hence in maintenance of individual systems. This maintenance disparity could adversely impact operation and maintenance.
- Once installed, any system that encounters an unexpected concentration peak may require modification and/or be temporarily bypassed.

2.4.1.2 Centralized Treatment Systems. A centralized treatment system would provide water obtained from the potentially affected areas. An extensive transport/distribution system would not be required; however, water users in the potentially affected areas are relatively far apart, and infrastructure (capital) costs could be relatively high compared to individual treatment systems.

The EEA will, however, have a treatment system onsite to treat groundwater extracted from the upper sand unit as part of the Phase I remediation. While this system is presently only conceptual in design, it theoretically could be used to provide a central water supply system for residences if they were to require alternate water supplies. Since the system is necessary for remediation, the additional capital costs will be relatively low--basically upgrading the system design to meet drinking water standards and providing for storage, transport, and distribution. Additional data would be required on the flow capacity of the planned extraction trenches; possibly extraction wells would be required instead to meet user demands.

Although this system appears economically and technically feasible, experience shows that treated contaminated water may not be readily accepted by the public as an alternate water supply. As a result, we did not evaluate this alternative further.

2.4.1.3 Surface Water Sources. Sources of raw surface water near the site would be limited to Little Northeast Creek or Little Elk Creek. Either of these sources would require some treatment prior to distribution. In addition, they would require construction of storage, transport, and distribution systems. The extent of construction would be dependent upon the proximity of the source of surface water to the affected residences. The nearby town of North East uses surface water from Little Northeast Creek for the public water supply system. The capacity of both Little Northeast Creek and Little Elk Creek would have to be evaluated in terms of water use needs. The treatment system for the upper sand unit proposed by the Phase I FS will possibly be discharging treated water to Mill Creek. This would affect flow rates for that surface water source.

These sources are technically feasible possibilities for alternate water supplies. Due to the extensive distribution involved, as well as the construction of an independent treatment system, this option is likely to be extremely expensive. Since the treatment and distribution of surface water as an alternate water supply will be at least an order of magnitude above other options in cost, it will not be recommended for detailed evaluation.

2.4.1.4 Extension of Existing Water Supplies. This option would involve extending the water supply system of Elkton to include affected residences.

Discussions with town officials indicate that this option is not currently feasible. Town restrictions, as well as water supply capacity, prohibit the construction of a pipeline from the town. Pipeline extensions may only be granted to service areas adjacent to the corporate limits of Elkton (the MSGS site is not), which may be annexed by the town. If local regulations or corporate limits change, this option could be reassessed (town of Elkton, 1988, personal communication).

2.4.2 Water Use Controls

Water use controls are applicable at sites where drinking water supplies are shown to have been adversely affected by site contaminants. Offsite drinking water has not been shown to be impacted by the MSGS site, thus further evaluation of water use controls is not performed.

Water use controls would involve ordinances prohibiting the use of groundwater on or near the site. A determination would be required of the area to

be under the ordinance and the length of time it would need to be in effect. These measures would need to be arranged through the local agencies and officials.

2.4.3 Groundwater Monitoring

Future monitoring of groundwater quality is an applicable management technology to evaluate the effectiveness of implemented remedial options and to assess the potential need for future expansion or reduction of the scope of remedial efforts to control contaminant migration. Some monitoring programs for groundwater define contaminant concentrations (action levels) that trigger specific actions, such as implementation of groundwater treatment or installation of point-of-use water treatment systems at specified locations where groundwater is being used for domestic purposes. Components of monitoring system plans include identification of:

- Appropriate analytes
- Sampling locations and frequencies
- Schedule for implementing expanded or reduced efforts, should they become necessary.

This management technology is particularly applicable at sites such as MSGS, where no evidence of adverse groundwater impact (in confined units) is present and contaminant source remedial measures (Phase I ROD) are already scheduled. This management technology will be further evaluated in subsequent sections of this FS.

TABLE 2-1
Summary of Preliminary Screening of Remedial Action Technologies

Response Action and Technology	Description	Comments	Potentially Applicable
<u>Groundwater and Surface Water Collection/Control</u>			
Pumping	Use of extraction wells to withdraw groundwater.	Withdrawing groundwater from middle and lower water-bearing units would increase the likelihood of contaminated groundwater being drawn from the upper sand unit. Difficult due to low hydraulic conductivities.	Yes (marginally)
Surface Water Diversion	Used to control the flow patterns of surface water and prevent the leaching of waste into groundwater.	No surface contaminant source at WEA. Surface water controls being implemented at EEA as part of Phase I ROD.	No
Subsurface Drains	Use of perforated conduit laid in trenches to intercept groundwater plume and carry collected water via gravity flow to a central collection point.	Affected water-bearing units are too deep.	No
Containment Barriers	A vertical wall(s) of low-permeability material constructed underground to divert groundwater flow or minimize leachate generation and plume movement.	Affected water-bearing units are too deep. Not practical to install in bedrock.	No
<u>Groundwater Treatment</u>			
Extraction/Air Stripping	Remove volatile analytes by increasing water surface area and inducing volatilization.	Requires groundwater extraction, which may cause unacceptable environmental hazards by contaminating deep water-bearing units onsite.	Yes (marginally)

TABLE 2-1 (cont'd)

Response Action and Technology	Description	Comments	Potentially Applicable
<u>Groundwater Treatment (cont'd)</u>			
Extraction/Carbon Adsorption	Remove hydrophobic analytes by passing water over bed of GAC.	Requires groundwater extraction, which may cause unacceptable environmental hazards by contaminating deep water- bearing units onsite.	Yes (marginally)
Extraction/Steam Stripping	Induce volatilization of analytes by heating influent to packed tower.	Requires groundwater extraction, which may cause unacceptable environmental and public health hazards.	Yes (marginally)
Discharge to Surface/ Pipe to Treatment Plant	Discharge treated groundwater to surface stream or pipe to offsite treatment location such as a sewage treatment plant.	Requires groundwater extraction, which may cause unacceptable environmental and public health hazards.	Yes (marginally)
In-Situ Biological Treatment	The stimulation of naturally occurring microorganisms to decompose indicator chemicals by the addition of nutrients and oxygen.	May require NPDES permit. Restrictions to groundwater pumping rates.	No
In-Situ Chemical Treatment			
Oxidation	Surface application or injection of a chemical additive to raise oxidation state of a compound. Can be used to degrade aromatics and/or strip halogens.	Indicator chemicals relatively nonbio- degradable. Low theoretical BOD. Low hydraulic conductivities, very hetero- geneous.	No
Reduction	Surface application or injection of a chemical additive to reduce the oxida- tion state of a compound through the use of catalyzed metals.	May not degrade chloroform due to contact difficulty. Unproven, technically in- feasible.	No
		Unproven for use with organics.	No

TABLE 2-1 (cont'd)

Response Action and Technology	Description	Comments	Potentially Applicable
<u>Groundwater Treatment (cont'd)</u>			
In-Situ Physical Treatment	Physical manipulation of subsurface to immobilize or detoxify waste constituents.	Best suited to shallow, homogeneous, permeable soil conditions. Unproven.	No
<u>Management Technologies</u>			
<u>Alternative Water Supplies</u>			
At-tap treatment	Activated carbon units installed on each water supply system between the well and the first point of use on the system.	Relatively high O&M costs. Proven, reliable.	Yes
Centralized treatment system	Use of treated water withdrawn from the upper sand water-bearing unit and treated as part of the Phase I remediation program.	Treated contaminated water may not be acceptable to public as drinking water supply.	No
Surface water sources	Withdraw, treat, and distribute surface water from Little Northeast Creek or Little Elk Creek.	Extremely high capital and O&M costs. Extensive pipe installation.	No
Extension of existing water supplies	Extension of water supply line from the town of Elkton.	Town ordinances and water supply capacity currently prohibit this option.	No
<u>Water Use Controls</u>			
Prohibit groundwater use	Ordinances or zoning to prohibit the use of groundwater in the affected area.	Residents would still require alternate water supply. Onsite restrictions should still be considered.	No

TABLE 2-1 (cont'd)

Response Action and Technology	Description	Comments	Potentially Applicable
<u>Management Technologies (cont'd)</u>			
Prohibit new large-quantity water users	Ordinances or zoning to prohibit the construction of businesses or industries that would use large quantities of water.	Would help slow potential offsite migration by keeping groundwater withdrawal to a minimum.	No
Groundwater Monitoring	Monitor analyte concentrations in ground- water to evaluate need for expansion or reduction of scope of remediation.	Assures protection of public health by monitoring effects of changing site con- ditions such as source controls under the Phase I ROD on concentrations of analytes.	Yes

3.0 DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

3.1 INTRODUCTION

In this section, applicable remedial technologies identified in Section 2.0 are assembled into various alternatives that address groundwater within the middle sand, lower sand, and bedrock units at the EEA and WEA. Remedial alternatives for other media (i.e., surface water and soils) at the EEA were evaluated in the Phase I RI/FS. At the WEA, remedial alternatives are not required for these media because the Phase II RI does not indicate that these media are sources of contamination.

In accordance with the NCP and USEPA guidance documents, alternatives are developed under the following guidelines:

- Alternatives that require no action.*
- Alternatives that do not attain applicable or relevant and appropriate requirements (ARAR's) for public health and the environment but will reduce the likelihood of a present or future threat from the hazardous substances and that provide significant protection to public health, welfare, and the environment. This category should include an alternative that closely approaches the level of protection provided by the ARAR's.*
- Alternatives that attain ARAR's for public health and the environment.
- Alternatives that exceed ARAR's for public health and the environment.
- Alternatives for treatment or disposal at an offsite facility, as appropriate.**

Descriptions are developed for each alternative to enable detailed evaluations to be carried out in Section 4.0.

Table 3-1 is a matrix that presents the applicable remedial technologies that passed the technology screening process. This matrix classifies the technologies into various alternatives.

*The Phase II RI found that ARAR's were met for the indicator chemicals under current site conditions.

**Offsite treatment or disposal is the least preferred alternative according to SARA.

3.2 ALTERNATIVE 1--NO ACTION

Alternative 1 fulfills the NCP requirement that a no-action alternative be considered within the context of the findings of the base line public health assessment. The Phase II EA illustrated that the average exposure concentrations for the Phase II indicator chemicals (excluding benzene in well D&M-12 because the blank was contaminated with benzene) detected in monitoring wells along the downgradient MSGS property boundary (D&M-2,3,5,6,7,12,13 and DMW-2,3) do not pose unacceptable health risks associated with potential future exposure to groundwater at the downgradient boundary. Exposure concentrations at the downgradient boundary are expected to decrease in response to controlling the source of the contaminants at the EEA during implementation of the Phase I ROD. Groundwater monitoring may be necessary to document the effectiveness of implementation of the Phase I ROD; therefore, the no-action alternative may not be appropriate.

3.3 ALTERNATIVE 2--ONSITE GROUNDWATER MONITORING

Alternative 2 provides for an assessment of whether observed analytes within the confined groundwater-bearing units are decreasing in response to Phase I remedial measures and natural attenuation mechanisms. Documentation of this situation would facilitate evaluation of the appropriateness of terminating cleanup of shallow groundwater at the EEA associated with the Phase I ROD implementation.

Onsite wells to be monitored would include:

<u>Middle Sand Unit</u>	<u>Lower Sand Unit</u>	<u>Bedrock Unit</u>
D&M-3	D&M-6	D&M-5
	D&M-11	D&M-7
	DMW-2	D&M-12

The unconfined upper sand water-bearing unit is excluded from the above summary because it will be closely monitored during implementation of the Phase I ROD. Figure 3-1 illustrates the locations of the above monitoring wells. These wells are generally located along the downgradient (southern) MSGS boundary and provide monitoring of each of the principal water-bearing units detected at this boundary during the Phase I and Phase II RI's.

Monitoring of the above locations would be implemented for a period of 5 years. After the initial 5 years, an evaluation would be made to assess the requirement to continue the monitoring program. The monitoring schedule during the first 5-year period would be:

- First Year--Quarterly sampling and analysis for volatile organic compounds (VOC's).
- Second Year--Semiannual sampling and analysis for VOC's.
- Third Year--Annual sampling and analysis for VOC's.
- Fourth and Fifth Years--Biennial sampling and analysis for VOC's.

The findings from this monitoring program will be forwarded to the appropriate USEPA and State reviewers. Requirements for modifying the monitoring program would be evaluated at that time.

3.4 ALTERNATIVE 3--ONSITE AND OFFSITE GROUNDWATER MONITORING

Alternative 3 consists of onsite and offsite groundwater monitoring. The onsite monitoring is identical in scope to the onsite monitoring program described for Alternative 2. Offsite monitoring would be conducted on an annual basis. Offsite monitoring encompasses four wells serving both residences and businesses as listed in Table 3-2. Figure 3-2 illustrates the locations of the proposed offsite wells to be monitored.

The locations of offsite wells to be monitored were selected to maximize the likelihood of detection of potential analytes from MSGS. Most of the locations are to the immediate south of MSGS, in the downgradient groundwater flow direction. The monitoring locations were also selected to provide coverage across the entire width of the MSGS property, to minimize the future possibility of groundwater analytes flowing between monitoring points.

A large-volume groundwater user is included in the monitoring plan to account for the possibility that groundwater analytes might preferentially be drawn toward this location. Available groundwater monitoring data do not indicate that this is occurring.

3.5 ALTERNATIVE 4--ONSITE AND OFFSITE GROUNDWATER MONITORING WITH IMMEDIATE ONSITE TREATMENT

Alternative 4 involves immediate onsite pumping and treating groundwater from the bedrock, lower sand, and middle sand water-bearing units combined with onsite and offsite groundwater monitoring. Groundwater treatment for this alternative involves carbon adsorption.

The monitoring portion of this alternative is the same as described for Alternative 3. The groundwater treatment portion of this alternative may have negative impacts on the groundwater quality within the confined water-bearing units if it is implemented before the contaminant sources (e.g., the perched water table aquifer, sediments, and soils at the EEA) are removed or controlled. Lowering of the hydraulic head by pumping from the confined and semiconfined water-bearing units may accelerate the rate of downward migration/infiltration of contaminated near-surface groundwater.

The extent to which groundwater pumping could cause leaching from the upper sand and gravel unit at the EEA, thus causing additional contamination of the underlying water-bearing units, depends somewhat on the competence of the upper confining clay that separates the upper sand and gravel unit from the underlying units. Well-defined groundwater seeps at the surface where the upper confining clay crops out, and the logs of borings from the EEA, suggest that the upper confining clay is rather competent and that direct leakage downward through this confining clay may not be the dominant pathway for induced leachate migration.

The more likely pathway for induced leachate migration is from the areas of the groundwater seeps (Sedge Meadow Area, area between pond PO1 and the swamp, and the area east of pond PO2). Lowering of the hydraulic head within the middle sand unit at these locations may encourage infiltration of contaminated seepage (discharging from the upper sand and gravel unit) directly into the middle sand water-bearing unit, which is unconfined in the vicinity of these seeps.

If the rate of induced contaminant influx exceeds the rate of contaminant removal by groundwater treatment and other natural attenuative mechanisms, then net groundwater quality will deteriorate. Contaminant removal rates from the confined/semiconfined water-bearing units at MSGS due to groundwater pumping/treatment are estimated to be low because of the poor water-producing capacity (low transmissivity) of these units. Simultaneously, the reduction of

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hydraulic heads in response to pumping is estimated to be high because of the low transmissivities. This combination of low rate of contaminated groundwater removal and high potential for head reduction indicates that a groundwater pump and treat alternative may induce the spread of contamination if it is implemented before the leachate source (upper sand and gravel unit at the EEA) is controlled/eliminated.

An analytical groundwater flow model (Hantush and Jacob, 1955) for estimating changes in head in a leaky confined aquifer in response to pumping was used to estimate maximum steady-state groundwater extraction rates from the middle sand unit. The model is:

$$s = \frac{Q}{4\pi T} W(u, \frac{r}{B}) \quad (\text{Eq. 3-1})$$

where: $W(u, \frac{r}{B})$ = well function for uniformly porous leaky artesian aquifer with fully penetrating wells having no storage capacity and negligible aquitard storage and source bed drawdown changes (dimensionless)

$$\frac{r}{B} = \frac{r}{\sqrt{T/(P'/m')}} \quad (\text{dimensionless})$$

$$u = \frac{r^2 S}{4Tt} \quad (\text{dimensionless})$$

and P' = vertical permeability of the upper silt and clay unit (gpd/ft)

m' = saturated upper silt and clay unit thickness (ft)

T = middle water-bearing unit transmissivity (gpd/ft)

S = middle water-bearing unit storativity (dimensionless)

r = radial distance from production well (ft)

t = time after pumping started (day)

Q = pumping rate

s = drawdown (ft)

This model assumes:

- Vertical flow through the aquitard
- Horizontal flow through the aquifer
- No release of stored water from the aquitard
- Instantaneous recharge to the source bed
- Uniform aquifer and aquitard properties.

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Figure 3-3 illustrates the system being simulated. It roughly approximates conditions at MSGS, although the confined aquifer (middle sand unit) being simulated at MSGS is probably not completely saturated. The "aquifer" illustrated in Figure 3-3 corresponds to the middle sand water-bearing unit at the EEA. This unit is considered semiconfined because of overlying silt and clay layers (upper confining clay). Walton (1985) presents a computer program (see Figure 3-4) that calculates drawdown(s) in accordance with equation 3-1.

Several runs of this program were used to simulate the response to pumping a confined aquifer. Table 3-3 summarizes the various run inputs and results. This simplified modeling indicates that sustainable long-term pumping rates from the confined portion of the middle sand unit are very low (less than 5 gallons per minute). Associated drawdowns are large. This suggests that the potential for induced leakage is large (large increase in downward hydraulic gradient), while the mass rate of contaminated groundwater removal from the pumped aquifer is low. The potential leachate source (sediments and shallow groundwater at the EEA) should be remediated/controlled before a pump and treat option is implemented relative to the underlying water-bearing units to assure that large decreases in head associated with remedial pumping of the semiconfined middle sand water-bearing unit do not induce additional contamination of the middle sand water-bearing unit.

Large potential drawdown estimated by equation 3-1 is partly due to the competence (substantial thickness, low permeability, and significant areal extent) considered in the simulation representative of the upper silt and clay unit (aquitard overlying the middle sand water-bearing unit at the EEA). Therefore, the mechanism of induced leachate infiltration likely to occur if the middle sand water-bearing unit is pumped may be infiltration around the perimeter (roughly coincident with surface groundwater seeps at the EEA) of the upper silt and clay aquitard rather than direct infiltration through the upper silt and clay unit.

Pumping and treatment of groundwater from the confined and semiconfined water-bearing units of MSGS should only be considered for implementation after the potential contaminant sources within shallow groundwater, soils, and sediments at the EEA have been controlled or eliminated and if the onsite groundwater monitoring documents increase in analyte concentrations in the deeper water-bearing units despite implementation of the Phase I groundwater treatment system.

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3.6 ALTERNATIVE 5--ONSITE AND OFFSITE GROUNDWATER MONITORING
WITH DEFERRED OFFSITE AND/OR ONSITE TREATMENT

Alternative 5 is similar to Alternative 4, except that onsite treatment would not be implemented until contamination associated with the upper sand and gravel unit at the EEA was eliminated or controlled by implementation of the Phase I ROD and unless statistically significant increases in onsite analyte concentrations are observed. In addition, offsite treatment would be implemented if so indicated by offsite monitoring data. The decision process is shown in Figure 3-5.

Minor fluctuations of concentrations in onsite wells are expected in response to natural variations associated with sampling, analysis, site conditions, etc. Therefore, potential statistically significant increases would be identified using an appropriate statistical test. This test will be applied to each of the water-bearing units of concern (middle sand, lower sand, bedrock) to compare the ratio of the difference between means to the estimated standard error of the difference. The data to be compared for each unit are the average analyte concentrations from previous monitoring periods versus the most recent results under evaluation.

Information concerning the performance of the Phase I groundwater treatment system is necessary to provide for a detailed evaluation of this alternative. These data include water quality data acquired after implementation of the Phase I ROD to evaluate the effect that treatment of groundwater in the upper sand and gravel unit at the EEA may have on groundwater quality in the underlying confined and semiconfined units. Also, the method of disposal (gravity outfall line to discharge point south of the Old Sedimentation Pond or discharge into the onsite ponds) of treated effluent from the Phase I treatment system may reduce or increase recharge to the unconfined portion of the middle sand water-bearing unit along the western tributary to Mill Creek and at the Sedge Meadow Area. This would impact design alternatives for extracting groundwater from the units underlying the upper sand and gravel unit.

For offsite wells, detection of any of the contaminants of concern during a particular monitoring period would require immediate resampling of the affected offsite wells. Concurrently, bottled water for drinking purposes could be made available to the affected residence or business, on request. If any of the contaminants of concern are detected again after resampling, and no obvious

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offsite sources such as recent spills are identified as sources, then point-of-use activated carbon water treatment systems would be installed at the affected wells. Accompanying these treatment systems will be ultraviolet irradiation systems to discourage microbial growth, as required by Maryland State law. During installation of the water treatment systems, the offsite monitoring well network would be evaluated and expanded as necessary.

3.7 ALTERNATIVE 6--ONSITE GROUNDWATER PUMPING WITH OFFSITE DISPOSAL

Alternative 6 includes extraction of groundwater using groundwater extraction wells, followed by offsite treatment at an existing offsite wastewater treatment facility, or direct discharge to surface streams at MSGS. As previously discussed, pumping groundwater from the confined units of MSGS before implementation of the Phase I ROD may have negative impacts on groundwater quality. The closest existing wastewater treatment system that could potentially handle treatment of groundwater from MSGS is the municipal wastewater treatment system in Elkton, Maryland. Presently, there are no sewer lines connecting the area surrounding MSGS to this facility. Trucking of pumped groundwater to this facility or construction of a pipeline would be prohibitively expensive compared to the option of onsite treatment. Also, onsite treatment is a preferred option under SARA; therefore, offsite treatment of extracted groundwater is excluded from further evaluation.

TABLE 3-1
Remedial Action Alternatives and Their Associated Technologies

Technology	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
No action	X					
Groundwater monitoring (onsite)		X				
Groundwater monitoring (onsite and offsite)			X	X	X	
Groundwater pumping—after Phase I Cleanup					X ^a	
Groundwater pumping—immediate				X ^b		X
Air stripping/steam stripping				X	X	
Carbon adsorption				X	X	
Pipe offsite surface discharge						X
Point-of-use treatment—immediate						
Point-of-use treatment—indicated by monitoring					X	

^aAlternative 5 defers confined aquifer pumping until after cleanup of the EEA water table aquifer during Phase I ROD implementation.

^bAlternative 4 includes technologies that typically meet or exceed ARAR's at the source. However, due to the specific site hydrogeology at MSGS (leaky confining units, downward hydraulic gradient), immediate pumping may induce spread of contaminants and make attainment of ARAR's more difficult.

TABLE 3-2

Offsite Groundwater Monitoring Locations

<u>Well Designation</u>	<u>Facility Served</u>	<u>Location^a/Comments</u>
1	Residence	1,500 feet southeast of EEA (shallow well sampled in Phase I as RW-10; owner has recent bedrock well)
2	Residence	1,000 feet south of Old Sedimentation Pond, along Ephrata Lane (sampled in Phase I as RW-01)
3	Business (large-volume user)	1,000 feet southwest of Old Sedimentation Pond, along U.S. Route 40 (sampled in Phase I as RW-02)
4	Residence	500 feet south of WEA

^aSee Figure 3-2 for locations.

TABLE 3-3
Variable Inputs/Outputs for the Hantush-Jacob Model

Run	r (ft)	T (gpd/ft) ^a	S _b	P (gpd/ft ²) ^c	m' (ft) ^d	t (day) ^e	Q (gpm)	s (ft)
1	1	17	0.001	7 E-04	20	365	1	89
2	1	17	0.001	7 E-04	10	365	1	85
3	1	17	0.001	7 E-04	1	365	1	70
4	1	17	0.001	7 E-04	0.05	365	1	49
5	1	17	0.001	7 E-04	1 E-06	365	1	0.01

^aEstimated from slug tests performed at MSGS during the Phase II RI.

^bRepresentative value for confined aquifers (Driscoll, 1986).

^cEstimated from slug tests performed on the lower silt and clay confining unit at MSGS during the Phase II RI, assumed representative of upper confining silt and clay unit.

^dActual thickness of upper confining silt and clay unit varies from 10 to 30 feet, based on borings at EEA.

^eLong pumping period assumed to simulate steady-state/long-term pump and treat remediation.

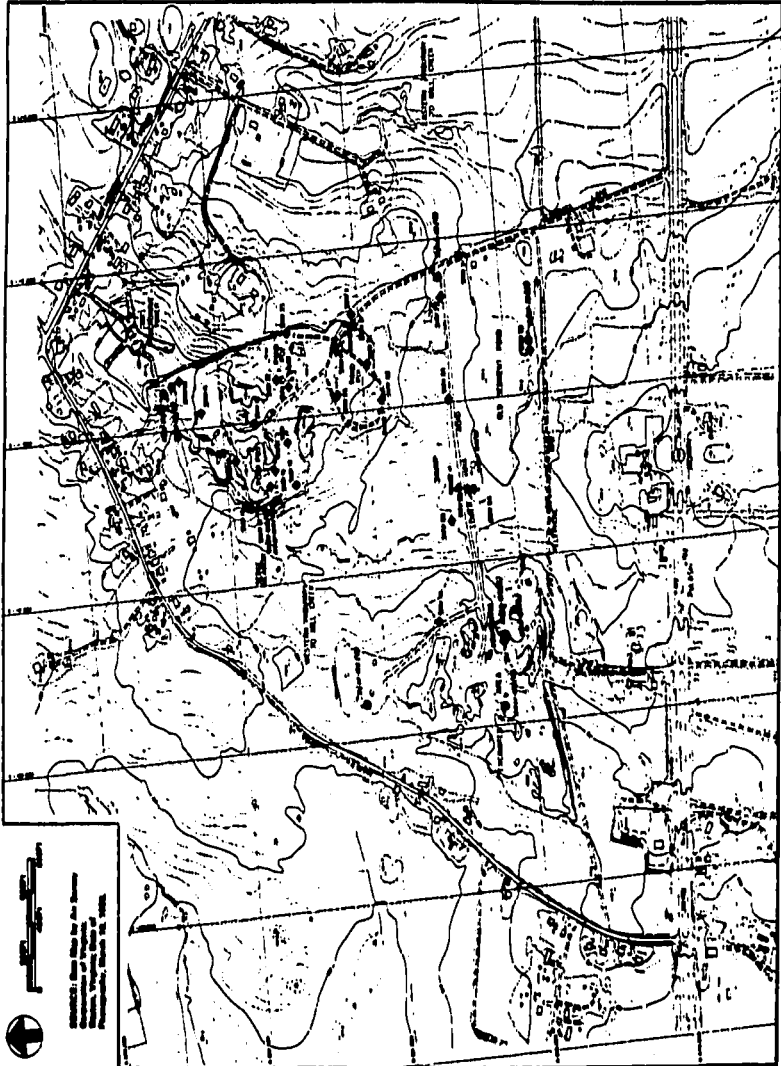
Notes

1. Runs 1 through 5—Leakage through aquitard (evidenced by decrease in amount of drawdown) is not significant until aquitard thickness (m') is substantially reduced; therefore, pathway for induced leachate infiltration is likely to be at perimeter (marked by surface groundwater seeps) of aquitard (upper silt and clay unit).

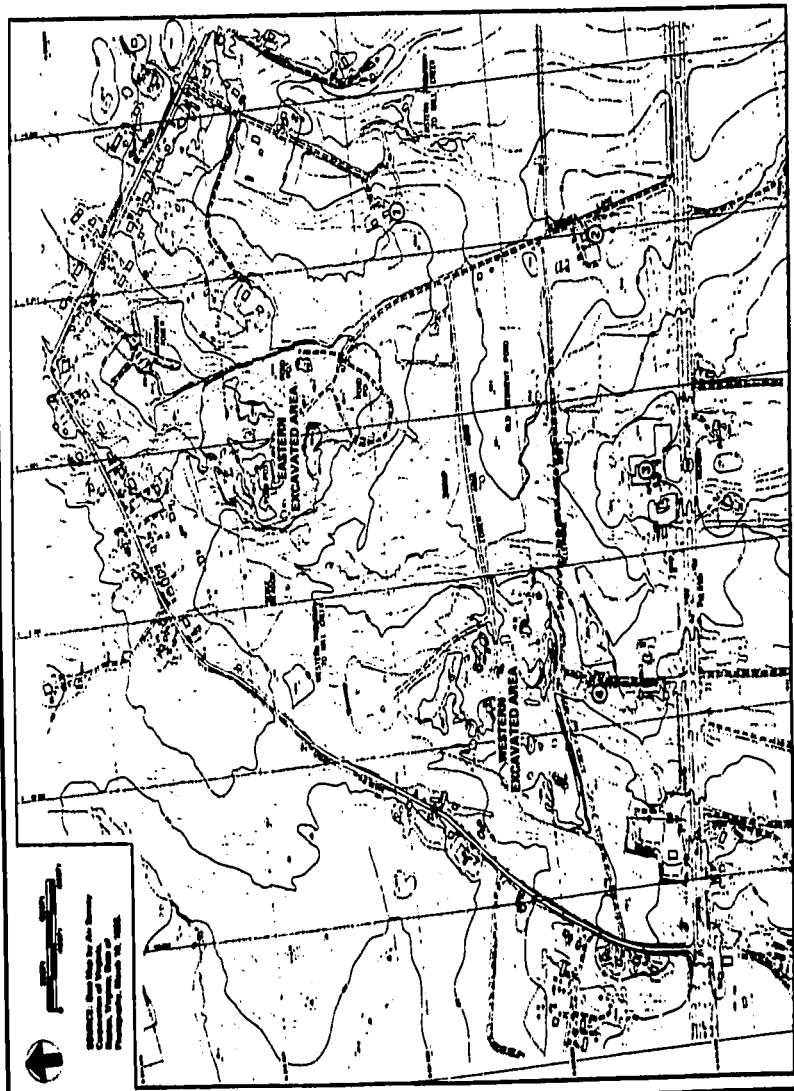
Wells Proposed for Ore Monitoring

Middle Sand: Dams 00, Dams 11, Dams 02
 Upper Sand: Dams 05, Dams 07, Dams 12
 Bedrock: Dams 05, Dams 07, Dams 12

FIGURE 3-1
LOCATION OF GRIFFIN
MONITORING WELLS



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KEY:
 ① Offsite Monitoring Well;
 ② Excavated Area;
 ③ Table 3.2

FIGURE 3.2
 LOCATION OF OFFSITE
 MONITORING WELLS

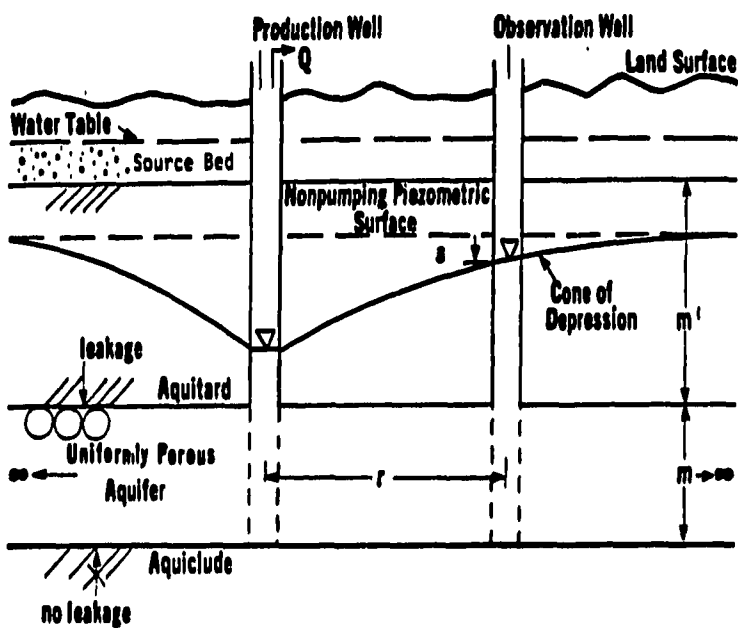


FIGURE 3-3
AQUIFER CONFIGURATION SIMULATED BY EQUATION 3-1

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Program listing (continued)

Walton B10

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1 CLEAR
2 CLS
3 PRINT"Program: WALTON - B10"
4 PRINT"Version: IBM/PC 3.0"
10 PRINT"Purpose: 2-LAYER AQUIFER SYSTEM-UNIFORM PROPERTIES;"
11 PRINT"    SINGLE WELL"
12 PRINT STRING$(32,45)
14 AFS="99.9999"
15 FILE=STRING$(30,45)
19 LPRINT CHR$(12);LPRINT"WALTON - B10";LPRINT FILE;LPRINT
20 INPUT"RADIAL DISTANCE TO WELL (FT)=";R
30 LPRINT"RADIAL DISTANCE TO WELL (FT)=" USING AFS;R
40 INPUT"AQUIFER TRANSMISSIVITY (BPD/FT)=";T
50 LPRINT"AQUIFER TRANSMISSIVITY (BPD/FT)=" USING AFS;T
60 INPUT"AQUIFER STORATIVITY (DIM)=";D
70 LPRINT"AQUIFER STORATIVITY (DIM)=" USING AFS;D
80 INPUT"AQUITARD VERTICAL PERMEABILITY (BPD/BD FT)=";P
90 LPRINT"AQUITARD VERTICAL PERMEABILITY (BPD/BD FT)=" USING AFS;P
100 INPUT"AQUITARD THICKNESS (FT)=";E
110 LPRINT"AQUITARD THICKNESS (FT)=" USING AFS;E
120 INPUT"TIME (DAY)=";Z
130 LPRINT"TIME (DAY)=" USING AFS;Z
140 INPUT"DISCHARGE RATE OF WELL (GPM)=";Q
150 LPRINT"DISCHARGE RATE OF WELL (GPM)=" USING AFS;Q
160 U=1.87*R^2*D/(T*Z)
170 S=R/(T*E/P)^.5
180 IF U>5 THEN LET NS=0;BOTO B10
190 IF S>2 THEN BOTO 460
200 IF U=1 THEN BOTO 220
210 MU=-LOG(U)/.577215660000005+.99999193000000068*U-.24991055*U+.0521997*
+3-.76004E-03*U^4+.1.07827E-03*U^5;BOTO 250
220 MU=U^4*.573328740100018*U^3+.18.0590169738*U^2+.8.6347608924999998*U+.2677737
3430000058
230 MU=MU/(U^4+.9.5733234540000078*U^3+.25.63295614868*U^2+.21.09965308278*U+.3.9584
969228000058)
240 MU=MU/(U*EXP(U))
250 L=8/3.75
260 V=1+.3.51562298*L^2+.3.08994248*L^4+.1.20674928*L^6+.265973*L^8+.0360768*L^10+.
0045813*L^12
270 F=8/2
280 W=-LOG(F)/V-.5772156600000005+.422784*F^2+.230697568*F^4+.0348859*F^6+.2.626
98E-03*F^8+.0001075*F^10+.0000074*F^12
290 IF S=0 THEN LET NS=MU;BOTO B10
300 N=S^2/(4*U)
310 IF N>5 THEN LET NS=2*N;BOTO B10
320 IF U<.9 THEN BOTO 350
330 A=U+.8058;B=U+.3.414;C=S*5/4
340 NS=1.5637*EXP(-A-C/A)/A+.4.84*EXP(-B-C/B)/B;BOTO B10
350 IF U<.05 THEN BOTO 390
360 IF U>8/2 THEN BOTO 380
370 C=-(1.75*U)^.4888;NS=2*N-4.8*10^C;BOTO B10
380 NS=MU-(8/(4.7*U^.6))^2;BOTO B10
390 IF U>.01 AND S<.1 THEN BOTO 380
400 IF N<1 THEN BOTO 440
410 MN=N^4*.8.573328740100018*N^3+.18.0590169738*N^2+.8.6347608924999998*N+.2677737
3430000058
420 MN=MN/(N^4+.9.5733234540000078*N^3+.25.63295614868*N^2+.21.09965308278*N+.3.9584
969228000058)
430 MN=MN/(N*EXP(N));BOTO 450

```

FIGURE 3-4
PROGRAM CODE FOR HANTUSH-JACOB MODEL

30222L

Program Listing (continued)

Walton B10 (continued)

```
440 MN= -LOG(N)*.9999919300000018*N-.5772156600000008N-.249910254*N^2+.0231997*N
^3-.9.76004E-03*N^4+.1.07857E-03*N^5
450 WS=2*N-MN*(V);GOTO 510
460 M=-(18-2*U)/(2*U*.5)
470 IF M<0 THEN LET M=ABS(M);GOSUB 480;GOTO 500
471 GOSUB 180
472 WS=(3.1416/(2*5))*.5*EXP(-S)*N
473 GOTO 510
480 N=1/(1+.0705230784*N+.0422820123*N^2+.9.2705272000000014D-03*N^3+.1.52014E-04
*N^4+.2.76867E-04*N^5+.4.30638E-05*N^6)^16;RETURN
500 WS=(3.1416/(2*5))*.5*EXP(-S)* (2-N)
510 F=114.6*D*WS/T
520 LPRINT"DRAWDOWN (FT) =" USING AF5;F
521 PRINT;PRINT"DRAWDOWN (FT) =" USING AF5;F
530 END
```

FIGURE 3-4 (Cont'd)
PROGRAM CODE FOR HANTUSH-JACOB MODEL

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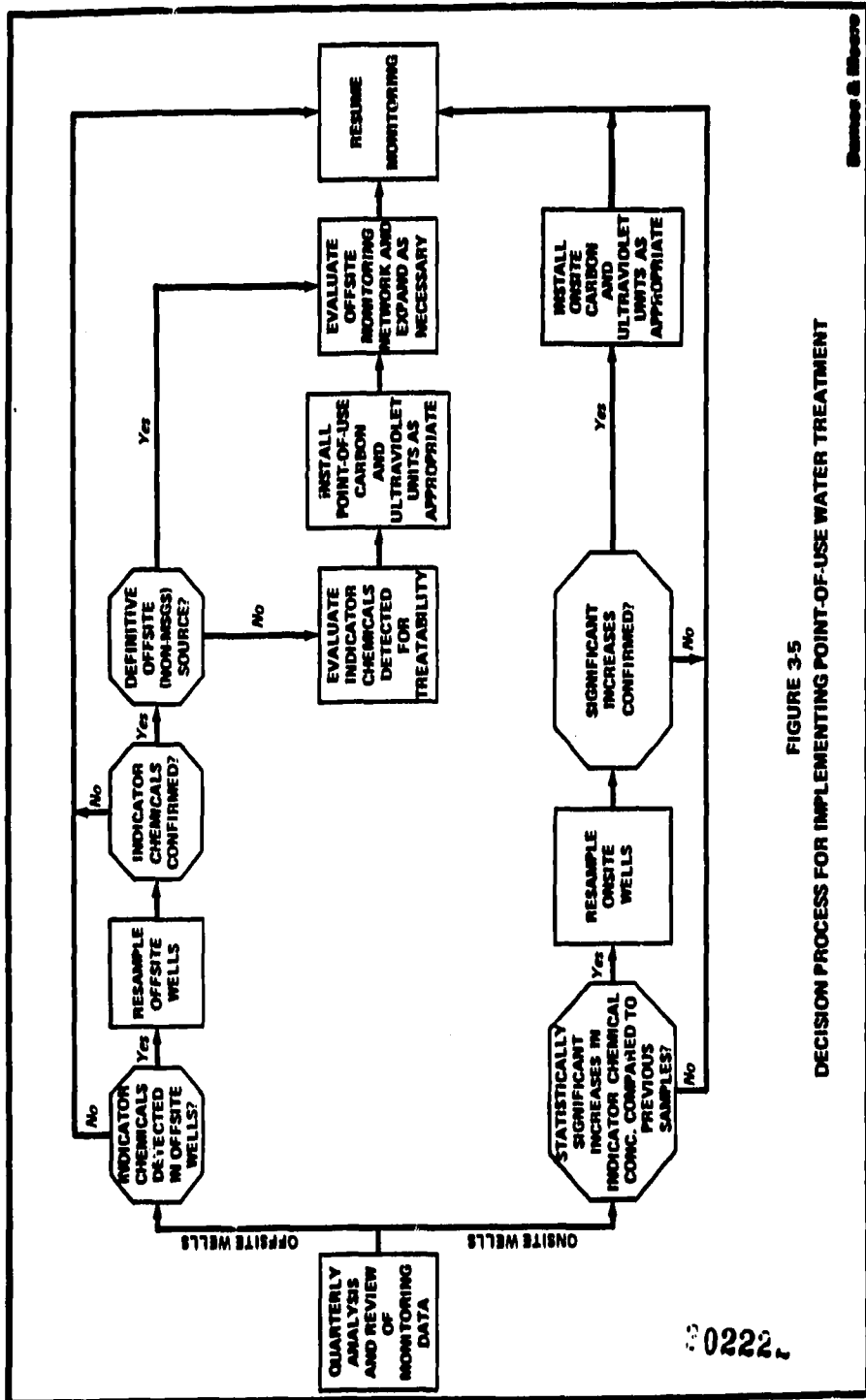


FIGURE 3-5
DECISION PROCESS FOR IMPLEMENTING POINT-OF-USE WATER TREATMENT

Source: E. Moore

4.0 DETAILED ANALYSIS OF ALTERNATIVES

4.1 EVALUATION CRITERIA

Each remedial action alternative carried through the detailed analysis will be evaluated on the basis of technical feasibility, environmental and public health impacts, legal and regulatory aspects, and cost. These criteria, in turn, involve several components designed to reveal the overall applicability of the alternative.

The alternatives will be compared on the basis of this screening. The USEPA considers the most crucial criteria to be technical feasibility, followed by environmental and public health, then legal and regulatory, with cost being the least important. Section 5.0 summarizes the results of this screening and presents the recommended alternative.

4.1.1 Technical Feasibility

The technical feasibility of the alternatives is based on four factors (outlined below). These criteria are intended to evaluate the technical factors of the physical construction, operation, and maintenance of the alternative.

4.1.1.1 Performance. Performance is assessed on the basis of effectiveness and useful life. Effectiveness, in turn, is based on the capacity of the technology to meet the response objectives. "Useful life" means the length of time that effectiveness can be maintained.

4.1.1.2 Reliability. Reliability is assessed on the basis of demonstrated performance and O&M requirements. Considerations include the potential for poor performance or failure of the system (or its components), the capacity of the system to accommodate variations between design criteria and actual field conditions, operational complexity, monitoring requirements, and the frequency of maintenance.

4.1.1.3 Implementability. The degree of implementability of a system is determined by the ease of installation, the time required to implement the technology, and the time required (after installation) for the technology to become effective.

4.1.1.4 Safety. Safety is evaluated in terms of the risk to environmental and public health in the event of system failure and in terms of the safety of workers,

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the public, and the environment during initial system construction and subsequent operation (USEPA, 1985a).

4.1.2 Environmental and Public Health

The environmental and public health screening evaluates both long- and short-term risks from the installation and operation of a system. Risks in the event of system failure are discussed in Section 4.1.1. For public health, risks could include noise or air pollution, odor, use of natural resources, aesthetics, and interference with public services or local businesses. Environmental risks could include acute or chronic toxic effects on plant or animal life, breeding cycle disruptions, alteration of wildlife habitat, and threats to protected plant and animal species.

4.1.3 Legal and Regulatory

Alternatives will be considered on the basis of compliance with applicable air, noise, and water standards; land use and zoning; and Federal, State, and local laws. The application of the regulations is described for each remedial alternative considered in this section.

4.1.4 Cost

Cost estimates will be presented with each alternative based upon available manufacturers' information, literature values, and experience. These cost estimates are intended for order-of-magnitude comparative purposes only, and actual implementation costs may differ. Estimates will be broken down into installation costs (capital) and O&M costs. All costs are presented in terms of 1988 dollars; totals are rounded to the nearest thousand dollars. Net present worths have been calculated using a discount rate of 10 percent for the life of the alternative.

4.2 NO ACTION

4.2.1 Technical Feasibility

Since the no-action alternative would not require any operational components, the four technical feasibility screening criteria cannot be applied.

4.2.2 Environmental and Public Health

Since no remedial measures would be taken under this alternative, risks to environmental and public health would remain unchanged from those determined in

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the Phase II RI Report; that is, risks would remain within the acceptable range, as defined by USEPA.

4.2.3 Legal and Regulatory

The EA conducted as part of the Phase II RI indicates no conditions that would be considered in exceedance of the appropriate legal and regulatory requirements. The no-action alternative would therefore also be in compliance with all applicable legal and regulatory mandates.

4.2.4 Cost

The no-action alternative would incur no capital or O&M costs.

4.3 ONSITE GROUNDWATER MONITORING

4.3.1 Technical Feasibility

This alternative would be technically effective and provide documentation of existing and future conditions at the site. The useful life of the system would be high and could be maintained at very low cost (basically well purging pump replacement on an as-needed basis). This alternative, again due to the simplicity of the system, would have a high reliability and implementability, and system failure would be unlikely.

Monitoring would be conducted on existing wells, thereby eliminating safety hazards from well installation. The monitoring itself would pose little or no risk to onsite workers and no risk to the public or the environment.

4.3.2 Environmental and Public Health

Although no unacceptable risks to the environment or public health are documented in the Phase II EA, the provision of onsite groundwater monitoring would provide a means to evaluate changing conditions. If unforeseen circumstances should arise, they would be detected and action taken. Onsite monitoring would also provide verification of the success of Phase I remediation.

The process of onsite monitoring itself would pose no threat to public health or the environment.

4.3.3 Legal and Regulatory

As stated for the no-action alternative, legal or regulatory requirements that are currently applicable to the portion of the site investigated in Phase II are met. The addition of onsite groundwater monitoring would not affect this condition.

This alternative would retain compliance with all relevant regulations, assuming that site conditions and applicable regulations remain unchanged.

4.3.4 Cost

This alternative proposes the monitoring of seven onsite wells for VOC's (see Figure 3-1) that would provide samples representative of the deep water-bearing units. Samples would be taken over a period of 5 years--quarterly in the first year, semiannually in the second year, annually at the end of the third year, and at the end of the fifth year (biennially). The costs associated with onsite groundwater monitoring are outlined below:

Onsite Groundwater Monitoring

Capital Costs (5-year replacement)

Pumps (\$300 ea.)	\$ 600
Bailers (\$100 ea.)	700
Miscellaneous Items (\$25/well)	<u>175</u>
Subtotal	\$ 1,475
Contingency (15%)	<u>220</u>
Total Capital Costs, per 5 years	\$ 1,695
	(\$2,000)

O&M Costs per Sampling Effort

Sampling ^a	4,525
Sample analysis ^b	5,715
Report preparation and sampling management	<u>\$ 1,000</u>
Subtotal	\$ 11,240
Contingency (15%)	<u>1,690</u>
Total Annual O&M Costs	\$ 12,930
	(\$13,000)

^aIncludes labor, per diem, supplies, etc.

^bIncludes analyses, blanks, containers, etc.

This alternative has a capital cost of approximately \$2,000 incurred over 5 years and an O&M cost of approximately \$13,000 per sampling effort. The net present worth of this alternative at a discount rate of 10 percent for 5 years is \$87,800.

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4.4 ONSITE AND OFFSITE GROUNDWATER MONITORING

4.4.1 Technical Feasibility

This alternative is similar in technical feasibility to the onsite monitoring alternative. The useful life of the system would be high and could be maintained at a reasonable cost. The use of existing residential or commercial wells further decreases the O&M requirements of this alternative. The simplicity of this alternative would make it highly reliable and easy to implement.

Safety hazards generated by well installation would be eliminated through the use of existing onsite and offsite wells. Monitoring either onsite or offsite would pose minimal risk to onsite workers, the public, or the environment.

4.4.2 Environmental and Public Health

This alternative, similar to onsite groundwater monitoring, would provide a measure of protection for the environment and public health above that being provided by Phase I and onsite monitoring alone.

This alternative would also be a direct and visible way of providing tangible assurance to the public that their health is being protected and that the quality of their drinking water is maintained. The process of onsite and offsite monitoring by itself poses no threat to public health or the environment.

4.4.3 Legal and Regulatory

As stated for the onsite groundwater monitoring alternative, legal or regulatory requirements that are currently applicable to the portion of the site investigated in Phase II are met. The addition of offsite monitoring would not affect this condition. This alternative would retain compliance with all relevant regulations, assuming that site conditions and applicable regulations remain unchanged.

4.4.4 Cost

This alternative proposes the monitoring of seven onsite wells and four offsite wells chosen to provide representative samples from the middle sand, lower sand, and bedrock water-bearing units. Samples for onsite wells would be taken on a schedule as described in Section 4.3.4 and submitted for review on the same schedule. Offsite wells would be sampled annually. All samples would be analyzed for VOC's using the Contract Laboratory Program (CLP) methods. The costs associated with onsite groundwater monitoring are the same as those outlined in

the previous alternative (Section 4.3.4). The additional costs associated with offsite monitoring are detailed below:

Onsite and Offsite Groundwater Monitoring

Capital Costs (5-year replacement)

Offsite monitoring--equipment	\$ 200
Contingency (15%)	30
Subtotal	\$ 230
Onsite monitoring capital costs	1,695
Total Capital Costs for Onsite and Offsite Monitoring	\$ 1,925
	(\$2,000)

O&M Costs Per Sampling Effort

Sampling ^a	\$ 1,250
Sample analyses ^b	2,820
Report preparation and sampling management	430
Subtotal	\$ 4,500
Contingency (15%)	675
Onsite monitoring O&M costs	12,930
Total O&M Costs for Onsite and Offsite Monitoring per Sampling Effort	\$ 18,105
	(\$18,000)

^aIncludes labor, per diem, supplies, etc.

^bIncludes analyses, blanks, containers, etc.

This alternative would have a capital cost of approximately \$2,000 incurred once in the 5-year period and O&M costs of approximately \$18,000 per sampling effort. The net present worth of this alternative at a discount rate of 10 percent for 5 years is \$108,000.

4.3 ONSITE AND OFFSITE GROUNDWATER MONITORING WITH DEFERRED OFFSITE AND/OR ONSITE TREATMENT

4.3.1 Technical Feasibility

The technical feasibility of this alternative would decrease somewhat with each level of increasing technology. Onsite and offsite groundwater monitoring (as

discussed in Sections 4.3.1 and 4.4.1) have relatively high implementability, reliability, and useful lives, and low O&M costs.

Individual carbon adsorption units on offsite wells, on the other hand, are more complicated to implement. Each system must be customized to conform to the existing space and piping layouts. While reliable, the units require periodic maintenance, inspection, and carbon replacement, thereby generating sizeable O&M costs. Offsite groundwater monitoring would ensure that system failure would be identified and corrected well before the E-06 risk.

The further addition of onsite treatment could prove to be difficult to implement, depending on the final design and performance of the Phase I water treatment. Treatability studies for a pump and treat program for groundwater would be required before final designs could be initiated. Presently, it is anticipated that onsite treatment would be feasible. Should this phase of the alternative prove necessary, it is recommended that the various options for groundwater treatment (use of Phase I system, etc.) be readdressed in light of then-existing site conditions. At that time, the technical feasibility of the option can be revised and updated.

4.5.2 Environmental and Public Health

Although no unacceptable risks to the public health or the environment have been identified, the provision of monitoring and treatment on an as-needed basis would provide a measure of protection in the event of unforeseen circumstances.

The public health concerns associated with the use of activated carbon units at well heads principally include proper disposal of the used carbon bed and providing for prompt maintenance and trouble shooting expertise in the event that a unit would malfunction. After extended periods of operation, the unit could become enriched in adsorbable organics from the groundwater being treated, and could represent a potential legal liability and public health threat if the unit were not properly handled and disposed. Such legal and potential health risks could be avoided easily by requiring appropriate documentation from the supplier of the GAC unit to assure that their servicing contract includes disposal or regeneration of the unit.

Potential risks from malfunction of an activated carbon unit and subsequent exposure of the groundwater users to untreated groundwater can be reduced to

acceptable levels by providing residences with a telephone contact to request assistance if malfunction is suspected and by providing periodic effluent sampling to monitor for breakthrough.

The potential health and environmental concerns of the possible future implementation of an onsite treatment program can only be generalized. Assuming the unit involved carbon adsorption, the same concerns about saturation, clogging, and proper disposal of used carbon that would apply to the individual point-of-use units would also apply to centralized treatment facilities.

4.5.3 Legal and Regulatory

As mentioned previously, applicable legal and regulatory requirements are being satisfied under current site conditions. Should treatment be reached in this alternative, several regulations may apply to the equipment and technical operation used. Both USEPA and the State of Maryland have requirements for home carbon units, which include:

- Carbon adsorption units for single-family residences must be at least 1½ ft³ in size, and a minimum of two must be used, placed in series.
- Carbon adsorption units must be followed by an ultraviolet unit to deter bacteria formed on the carbon from entering the water system.
- Used carbon must either be delisted, regenerated, or disposed of as a hazardous waste.

Final design plans should be reviewed and approved by the appropriate regulatory agencies. Onsite treatment units would be subject to regulation, permitting, discharge requirements, etc., depending on the type of treatment used.

4.5.4 Cost

Costs for this alternative will vary, depending upon the number and type of treatment units installed. A range of costs has been developed based on best-case (no treatment units necessary) and worst-case (treatment units required for all residences and businesses within the affected area within the first year) situations.

The additional cost of onsite treatment cannot be evaluated at this time. It is important to note that costs presented are order-of-magnitude estimates and are to be used for comparison purposes only. Actual costs may differ.

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The costs for the best-case situation would be the same as those developed for the onsite and offsite groundwater monitoring alternative (capital = \$2,000 per 5 years, O&M = \$18,000, net present worth = \$122,500).

The worst-case estimate (not including onsite treatment) is based on a maximum of 25 residences and three businesses requiring installation of water treatment systems. Costs for the treatment systems were based on vendor quotes for installed units (Culligan, 1988); where applicable, unit costs are given. Costs for carbon adsorption units include two 1½-ft³ units, three sampling ports, a water meter, and an ultraviolet light system. This case would have a capital cost of \$75,800, O&M costs of \$32,300 per year, and a net present worth of \$394,800. Monitoring and O&M on all units would continue on a biennial basis for 30 years.

Carbon Adsorption Units

Capital Costs

Single-family home units (25)	\$ 32,500
Businesses (3)	<u>11,700</u>
Subtotal	\$ 64,200
Contingency (15%)	9,630
Onsite and offsite groundwater monitoring capital costs, per 5 years	<u>1,925</u>
Total Capital Costs	\$ 75,755
	(\$76,000)

Annual O&M Costs

Replacement carbon, disposal of used carbon (\$350 ea. for all units)	\$ 9,800
UV lamps (\$80 to \$100 per unit per year)	<u>2,500</u>
Subtotal	\$ 12,300
Contingency (15%)	1,850
Onsite and offsite groundwater monitoring O&M costs, per sampling effort	<u>18,105</u>
Total Annual O&M Costs	\$ 32,255
	(\$32,000)

The worst-case option (not including onsite treatment) would have a capital cost of approximately \$76,000, an O&M cost of \$32,000, and a net present worth (30 years, 10 percent) of \$354,000.

4.6 SENSITIVITY ANALYSIS

Tables 4-1 and 4-2 present a sensitivity analysis, assessing the effect of variations in specific assumptions on the overall present worth costs of each alternative. Table 4-1 shows the effects of a variation in costs of plus or minus 30 percent on the cost of each alternative, holding all other variables constant. The table shows that the capital-intensive alternative--onsite and offsite groundwater monitoring with deferred offsite and/or onsite treatment--is most sensitive to variations in capital cost, as would be expected.

Table 4-2 shows the effect of a variable discount rate on overall site alternative costs, as well as a variable duration of remediation. The effect of a variable discount rate would exert the greatest effect on alternatives having higher O&M costs, as would be expected. The third and fourth alternatives would have the highest proportion of O&M costs and would consequently be the most affected by a variation in the discount rate.

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TABLE 4-1
Sensitivity Analysis--30% Variation in Costs

Alternative	Capital Costs ^a (\$ x 1,000)			O&M Costs ^a (\$ x 1,000)		
	Original Estimate	+30%	-30%	Original Estimate	+30%	-30%
No Action	0	0	0	0	0	0
Onsite Groundwater Monitoring	2	2.0	1	13	17	9
Onsite and Offsite Groundwater Monitoring	2	3.0	1	18	24	13
Onsite and Offsite Groundwater Monitoring with Deferred Offsite and/or Onsite Treatment (worst case)	76 ^b	99 ^b	53 ^b	32 ^b	42 ^b	23 ^b

^aAll costs are in 1983 dollars.

^bCost data for onsite treatment are not included.

TABLE 4-2
Sensitivity Analysis--Variation of Costs with Discount Rate and Remediation Time

Alternative	Original Estimate ^a	Discount Rate		Remediation Time Doubled
		5%	15%	
No Action	0	0	0	0
Onsite Groundwater Monitoring	83	96	81	101
Onsite and Offsite Groundwater Monitoring	108	118	99	133
Onsite and Offsite Groundwater Monitoring with Deferred Offsite and/or Onsite Treat- ment (worst case)	556 ^b	820 ^b	424 ^b	578 ^b

^aTotal program costs, present worth in 1988 dollars, 10% discount rate.

^bCost data for onsite treatment are not included.

5.0 RECOMMENDED REMEDIAL ALTERNATIVE

The detailed analysis of the remedial action alternatives in Section 4.0 is summarized in Table 3-1. This overview allows the four alternatives to be compared with regard to protection of public health and the environment, ability to meet remedial objectives (ARAR's), and cost considerations. Based on the results of the Section 4.0 analysis, onsite and offsite groundwater monitoring is the recommended Phase II remedial alternative for the MSGS site.

Reviewing the major screening factors used for each alternative, it can be seen that this remedial action has:

- Technical feasibility, using established practices
- No adverse effects to public health and the environment
- Minimal legal and regulatory uncertainty
- Acceptable levels of capital and O&M costs.

This alternative attains or exceeds ARAR-based remedial objectives at the site and is protective of human health and the environment while giving all parties maximum flexibility to adapt the remedial program to conditions at and near the site over time. Assuming that the Phase I remedy will be as effective as anticipated, then the alternative is supportive of a permanent solution to the maximum extent practicable.

This alternative was recommended over the onsite groundwater monitoring option due to the additional level of assurance provided to offsite water users. It is recommended over the last alternative, which additionally includes groundwater pumping and treatment, because of continuing uncertainties of the safety and effectiveness of pump and treat actions at the site, and the pending positive impact of the implementation of Phase I remedial action.

In conclusion, onsite and offsite groundwater monitoring meets the statutory requirements for a selected remedy and is an appropriate Phase II remedial action for the MSGS site.

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TABLE 5-1
Summary of Remedial Action Alternatives

Alternative	Costs (\$ x 1,000)			Meets or Exceeds ARAR's for Indi- cator Chemicals	Comments
	Capital	O&M	NPW ^a		
No Action	0	0	0	Yes	
Onsite Groundwater Monitoring	2	13	88	Yes	Provides for tracking of analytes onsite and warning of exceedances.
Onsite and Offsite Groundwater Monitoring	2	18	108	Yes	Provides for tracking of analytes onsite and offsite and warning of exceedances.
Onsite and Offsite Groundwater Monitoring with Deferred Offsite and/or Onsite Treatment	b 76	b 32	b 554	Yes	Similar to above, except that onsite and/or offsite treatment would be initiated if indicated by confirmed monitoring results.

^aNet present worth at 10%.

^bCost data for monitoring and offsite treatment only. Cost data for onsite treatment not generated until effectiveness of Phase I groundwater treatment system can be evaluated.

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